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Air Campaign Against the Iraqi Army in the Kuwaiti Theater of Operations

Fred Frostic

Project AIR FORCE

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Preface

The air campaign against Iraqi ground forces in the Kuwaiti Theater of Operations (KTO) during Operation Desert Storm represents a unique milestone in military history. This report describes the evolution of the campaign in the KTO and the planning and control of air operations, provides a qualitative assessment of the effectiveness of various systems employed against the Iraqi ground forces, and discusses the factors that led to the success of the operation.

The report is one of a series of publications that document the results of Project AIR FORCE's study of the Desert Storm air campaign. The study began in May 1991 under the sponsorship of the Air Force Vice Chief of Staff, and it was carried out within the Theater Force Employment Program of Project AIR FORCE. Its objectives are to describe and assess (1) the effectiveness of the air mission in Desert Storm at both the strategic and tactical levels in terms of the initial and evolving campaign objectives, (2) the use of airpower as the major instrument of forcing the withdrawal of Iraqi forces from Kuwait and the implications for future Air Force doctrine, missions, systems, logistic needs, force modernization, and research and development, and (3) the planning and execution of Desert Storm in terms of the doctrine for joint and U.S. and allied operations.

Other publications address a range of topics including the contribution of the bomber force, battle damage assessment, C3I, the U.S. Air Force Central Command Master Attack Plan, close air support operations, munitions support for USAF aircraft, logistics and other support for USAF tactical aircraft, composite wing operations, air attack against the Iraqi army in the KTO, the USAF rapid response process for streamlined acquisition during Desert Shield and Desert Storm, strategic airlift, the Civil Reserve Air Fleet, and the effectiveness of precision munitions against hardened shelters.

This report was originally drawn from interviews and classified source documents. It has been modified to permit publication as an unclassified report in accordance with the DoD Classification Guidance for Post-Operation Desert Storm Information.

In doing the research for this report, we concentrated on the conduct of the campaign and the successes and problems that were encountered in KTO air operations. We recognize that many other air operations were simultaneously under way as the Iraqi army was being engaged and attrited. Air-to-air missions,

strategic attack, maritime air operations, and the "Scud hunt" were all important parts of the overall air and surface campaign during Desert Storm.

Throughout this report, we focus on the application of airpower against enemy land forces. We do not distinguish between the service or nationality of the aircrews who conducted the operation. Because this study was undertaken for the U.S. Air Force, we had the active cooperation of USAF participants. Therefore, our depth of knowledge of USAF participation is necessarily greater. However, we appreciate that Desert Storm was a joint undertaking in which all elements of the coalition contributed to the overall success.

These publications should prove useful to those interested in any aspect of tactical air operations, particularly those addressing the doctrinal implications of Operation Desert Storm.

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Summary

The air campaign against the Iraqi army in the Kuwait Theater of Operations (KTO) began on the opening day of the war. Eighty B-52s bombed Republican Guard positions, almost 300 A-10 sorties were flown against troop positions along the border, and F-16s attacked ground force command and control positions. Additionally, over 250 other sorties were flown in the KTO on the first day of the war against strategic air offensive targets. The number of attack sorties rose to over 1000 a day in the ensuing weeks.

The campaign against the Iraqi ground forces comprised several objectives of the larger air campaign. The objectives of the KTO campaign were to

- Gain air supremacy in the KTO by suppressing air defenses
- Isolate the Iraqi forces in Kuwait
- Render the Iraqi army ineffective
- Support coalition ground forces in the execution of the ground campaign.

The nature of the campaign against the Iraqi forces changed over the six-week period as the conditions of combat evolved and the demands of the battlefield emerged. A significant factor that shaped the character of the war in the KTO was the speed at which the radar-guided surface-to-air missiles were suppressed. Within days, coalition air forces could operate with near impunity, above the effective range of antiaircraft guns. This freedom permitted time to search for and engage Iraqi ground force units and support elements throughout the theater.

The initial attacks in the KTO were conducted principally by F-16s, A-10s, AC-130 gunships, Marine AV-8Bs and F/A-18s, and B-52s. The pace of attacks in the KTO waned toward the end of the first week with bad weather and the diversion of aircraft to Scud hunting. Then the tempo resumed, and new procedures and tactics were employed to increase the effectiveness of the campaign.

Just before the battle of Khafji, F-15Es began working directly with Joint Surveillance and Target Attack Radar System (STARS) aircraft to engage moving vehicles and radar-detectable ground positions at night. As increasing attention was directed to the rate of attrition of Iraqi forces, new tactics were developed to

increase effectiveness on the static battlefield. F-16s began performing the "Killer Scout" mission after the first of February. In this role, a two-ship flight of F-16s or F/A-18s would survey the targets in a 30 by 30 nautical mile "kill box" in central Kuwait and southern Iraq and direct attack flights against positions with active targets. The Killer Scouts operated during daylight hours.

Several days after the Killer Scouts began operations, F-111Fs started "tank plinking." This activity entailed the detection of armored vehicles with the infrared "Pave Tack" sensor on the F-111Fs and the destruction of the armor with laser-guided bombs. F-15Es and A-6Es later participated in tank plinking.

Beginning on February 15, a portion of the air campaign in the KTO focused on the neutralization of Iraqi artillery and the defensive emplacements along the border. Various aircraft and weapons were used to reduce the front line defensive positions. As a result, the breaching operations went quickly and with almost no casualties.

During the unexpectedly short four-day ground war, many sorties were planned for close air support, but there was little demand for it because of the success of the earlier air campaign and the rapid movement of ground forces. Instead, coalition airpower was used well in front of the advancing ground units. The dramatic pictures of the burning vehicles along the road to Basra demonstrate the ability of the coalition air forces to engage and destroy Iraqis wherever they moved.

The air campaign against the Iraqi ground forces was planned and executed within a defined structure. Attacks against the tactical echelon of the Iraqi army were controlled by OA-10s and OV-10s. Throughout the tactical echelon, attacks were designated as close air support and required permission of the ground commander. A-10s and AV-8Bs conducted most of the attacks in this area.

North of this zone in a band 60 nautical miles wide, attacks were directed by the Killer Scouts during the daytime. Most of the Republican Guard divisions and the operational reserves of the Iraqi army were in this area. F-16s and B-52s began this effort and were later joined by the tank plinking F-111Fs, F-15Es, and A-6s. A steady buildup of sorties of F/A-18s, A-6s, and the coalition forces contributed to the effort in this area. Beyond 30°30'N in the KTO, flight-lead controlled interdiction was conducted. The Airborne Warning and Control System provided flights operating in this area with target updates based on information passed from surveillance assets and other flights.

The outcome of the campaign against the Iraqi forces was a direct product of planning and battle management. The scope and complexity inherent in

planning a high-tempo air campaign involving over 2000 sorties per day dictated that planning be conducted two days or more before missions were flown. A battle management system was used, operating within the campaign framework described above, to focus attack flights as the tactical situation shifted.

The planning process and battle management system functioned in conjunction with an imperfect battle damage assessment (BDA) system. BDA assumed increased importance in Desert Storm because the war was conducted on a very tight "schedule." The schedule depended upon specific goals such as the attrition of the combat power of the Iraqi army by 50 percent. Combat power was measured in terms of tanks, armored personnel carriers, and artillery. The difficulty with the BDA process is that it evolved as the war was taking place. Further, because the rate at which the Iraqi army was attrited was critical, many agencies (Defense Intelligence Agency, Central Intelligence Agency, U.S. Central Command, and operational units) kept score using the assets and methods available to them. Naturally, there was not a high degree of correlation between the different assessment processes.

An important and impressive aspect of the planning and control system was its institutional adaptability. The war lasted only six weeks. Over this short time span, new operational concepts for tasks such as Scud hunting, Joint STARS targeting, Killer Scouts, and tank plinking were conceived, developed, and implemented. The history of warfare is full of stories of fighter pilots devising innovative tactics. However, in the past it took a long time to formally adapt new operational concepts. In Desert Storm, new concepts were incorporated in the Air Tasking Order in less than a week from inception.

Desert Storm affirmed the capability of weapons that were developed and fielded after the Vietnam War. It also demonstrated that well-trained people can take new systems and make them work effectively in combat. The effect of these systems provided a taste of the changing nature of modern air-land warfare.

Air superiority, the ability to operate without significant interference from enemy aircraft and surface-to-air defenses, was a key accomplishment early in the campaign. Once established, attack flights had time to search for targets and signs of Iraqi ground force activity, making it extremely dangerous and very difficult for ground forces to move. Without the ability to move, the Iraqi army was consigned to a steady process of attrition.

Joint STARS was new and operated only at night. However, it demonstrated its potential to detect and direct fighters to engage moving ground forces. It takes ground forces longer to reach their destination than it does for Joint STARS to detect them and divert aircraft to attack them. This capability was demonstrated

against the reinforcing divisions for the Battle of Khafji (January 30–31) and the flight to Basra (February 26–27). The ability to detect ground force and logistics movements at depth makes the battlefield truly nonlinear.

Precision munitions have been fielded for two decades. They have been successfully tried in combat a number of times. Desert Storm, however, conclusively demonstrated the value of these weapons. The effect of many precision-guided munitions (PGMs) was a key factor in this war and promises equal effect in future wars. A somewhat surprising result of PGM employment in Desert Storm is that their effectiveness correlated very closely to the results achieved with these weapons in testing, training, and exercises. The effect of PGMs presents a new set of challenges and opportunities for future campaign planning.

Desert Storm was the first time that *successful* large-scale night air operations have been conducted. Forward-looking imaging infrared sensors, effective munitions, and well-trained people made this difficult undertaking possible. Night air operations provide a sanctuary against some defenses and add 24-hour pressure against the enemy. These operations are now a reality.

Finally, it should be remembered that despite the favorable conditions established by the coalition air forces, time and numbers were needed to complete the task. A dispersed, static, and camouflaged field army presents a large number of targets. Precision weapons make the defeat of an army from the air feasible, but once the situation becomes static, the attrition process is completed one target at a time.

The accomplishments of the coalition air forces in Desert Storm were revolutionary in the history of warfare. Forty-two divisions had their combat power reduced over a third in 38 days. Perhaps half the Iraqi troops deserted over this period. Although the results are quantified in terms of equipment destoyed and the number of desertions, the cumulative effect of air operations against the Iraqi force was to destroy their will to fight, leading to their surrender. The coalition ground campaign, which had been planned to last two weeks, took less than four days with 78 friendly force personnel killed in action. A blending of technology, conditions, leadership, and, most important, well-trained people made it happen.

Acknowledgments

I would first like to thank the men and women who participated in Operation Desert Shield/Storm. Their determination, skill, flexibility, and sacrifices made this tremendous operation a success. Only those who took part in this operation can appreciate the depth of committment needed to complete an operation of this scale.

I want to give special thanks to Theodore Parker for the leadership, organization, and devotion he gave to the Project AIR FORCE Desert Storm analysis effort. Additionally, Desert Storm participants from the 9th and 12th Air Forces and from the Air Force and Navy fellows at RAND provided invaluable assistance. Sarah Young displayed great initiative and patience in the production of this document.

List of Symbols

AA	Antiaircraft
AAA	Antiaircraft Artillery
ABCCC	Airborne Command and Control Center
ACE	Alternate Command Element
ACO	Airspace Coordination Order
AFAC	Airborne Forward Air Controller
AI	Air Interdiction
APAM	Anti-Personnel Anti-Materiel Munition
APC	Armored Personnel Carrier
ARBS	Angle Rate Bombing System
ARCENT	U.S. Army Central Command
ASARS	Advanced Synthetic Aperture Radar System
ASOC	Air Support Operations Center
ATO	Air Tasking Order
AWACS	Airborne Warning and Control System
BDA	Battle Damage Assessment
C3	Command, Control, and Communications
CAP	Combat Air Patrol
CAS	Close Air Support
CBU	Cluster Bomb Unit
CCIP	Continuously Computed Impact Point
CENTAF	U.S. Air Force Central Command
CENTCOM	U.S. Central Command
CEP	Circular Error Probable
CIA	Central Intelligence Agency
CINC	Commander in Chief
DASC	Direct Air Support Center
DBS	Doppler Beam Sharpening
DIA	Defense Intelligence Agency
ECM	Electronic Countermeasure
EO	Electro Optical
EPW	Enemy Prisoner of War
EW	Electronic Warfare
FAC	Forward Air Controller
FLIR	Forward-Looking Imaging Infrared Radar
FSCL	Fire Support Coordination Line
GBU	Guided Bomb Unit
GFAC	Ground Forward Air Controller
GLO	Ground Liaison Officer
GMTI	Ground Moving Target Indicator
GMTT	Ground Moving Target Track
GP	General Purpose
GPS	Global Positioning System
HARM	High-Speed Anti-Radiation Missile
HF	High Frequency

IIR	Imaging Infrared
IR	Infrared
JAAT	Joint Air Attack Tactics
JFACC	Joint Force Air Component Commander
Joint STARS	Joint Surveillance and Target Attack Radar System
KTAS	Knots True Air Speed
KTO	Kuwaiti Theater of Operations
LANTIRN	Low-Altitude Navigation and Targeting Infrared at Night
LGB	Laser-Guided Bomb
LOC	Line of Communication
MAP	Master Attack Plan
MARCENT	U.S. Marines Central Command
MISREP	Mission Report
MTI	Moving Target Indicator
NAC	North Army Corps
PGM	Precision-Guided Munition
RAF	Royal Air Force
SAM	Surface to Air Missile
SAR	Synthetic Aperture Radar
SEAD	Suppression of Enemy Air Defenses
SLAM	Standoff Land-Attack Missile
SPINS	Special Instructions
SWIP	System Weapons Improvement Program
TACC	Tactical Air Control Center
TALD	Tactical Air-Launched Decoys
TARPS	Tactical Aerial Reconnaissance Pod System
TFW	Tactical Fighter Wing
TIALD	Thermal Imaging Airborne Laser Designator
TLAM	Tomahawk Land-Attack Missile
TOC	Tactical Operation Center
TOD	Time of Day
TOW	Tube-Launched Optically Tracked Wire-Guided Missile
UHF	Ultra High Frequency
V/STOL	Vertical/Short Takeoff and Landing
VTR	Videotape Recorder
WSEP	Weapon System Evaluation Program

1. Introduction

The joint air and ground campaign to defeat the Iraqi army in Kuwait began at the very outset of Operation Desert Storm on the night of January 16. Shortly after the laser-guided bombs (LGBs) from F-117 stealth fighters began their impact on critical command, control, and communications nodes in Baghdad, attacks were launched against the Republican Guard divisions in the Kuwaiti Theater of Operations (KTO). The joint campaign against the Iraqi Field Army ended 42 days later when President Bush announced the cease-fire on February 28. As a result of this integrated joint campaign, Kuwait was free again and the Iraqi army was rendered combat-ineffective and was expelled from Kuwait.

The Air Campaign

The employment of various elements of the coalition forces to defeat the Iraqi Field Army in the KTO was part of the larger air campaign in Operation Desert Storm. The concept of operations for the Desert Storm air campaign was initially planned to occur in distinct phases, which were to be separated in time as shown in Figure 1.1.

- Phase I was envisioned as a seven-day effort to gain air superiority, destroy the Iraqis' ability to deliver weapons of mass destruction, and cause strategic paralysis within Iraq through disruption of the command and control infrastructure.
- Phase II was to be a three-day operation to suppress the surface-to-air defenses in the KTO.
- Phase III was conceived as an increasing concentration on the Iraqi ground forces in the KTO. During this phase, targets identified and attacked during the first two phases were to be subjected to follow-on attacks as the tactical situation dictated. Phase III was expected to be completed around Day 30.
- Phase IV was to be massed air support for offensive allied ground force operations.

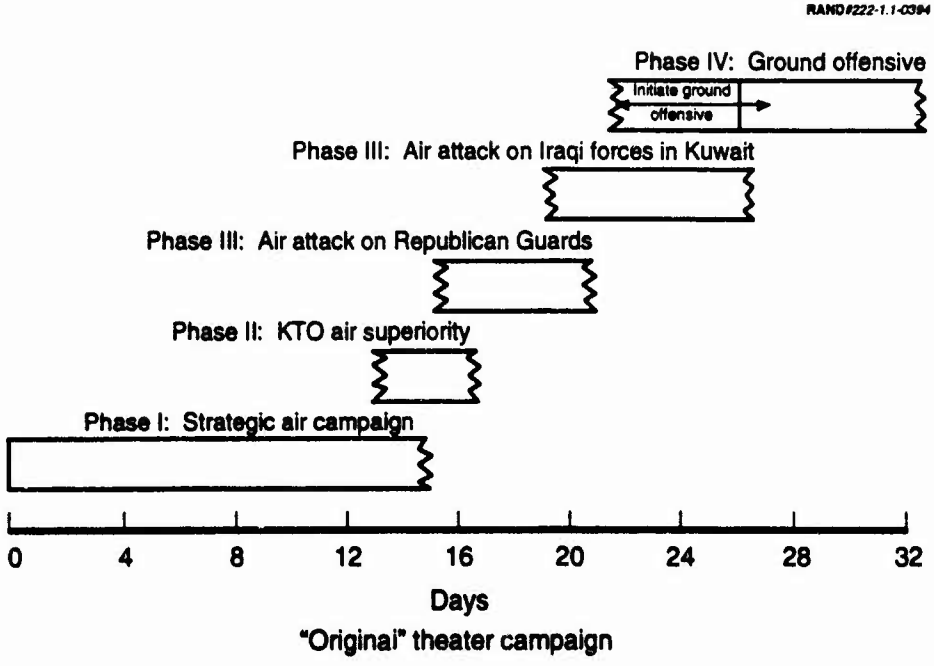


Figure 1.1—Air Campaign Plan: Initial Concept

However, because there were sufficient air forces available by January 1991, it was decided to execute the first three phases simultaneously to apply the greatest amount of pressure on Iraq from the beginning of the war.

The Phase I objectives of gaining air superiority and disrupting the Iraqi command and control were achieved quickly and decisively. Within three days, the Iraqi air force was essentially grounded, awaiting methodical destruction on their airfields. Similarly, through the elimination of key C3 nodes and the electrical power supply in Iraq, the capacity of the Iraqis to direct their combat forces was substantially reduced.

The Phase I objective of destroying the Iraqi arsenal of weapons of mass destruction and the ability to deliver them was a larger task than anticipated, because of the number and dispersal of their surface-to-surface missiles and the difficulty of locating mobile launch platforms.

The objective of Phase II was met in the first few days through the virtual elimination of Iraqi radar surface-to-air missile (SAM) sites and the use of tactics to avoid the remaining threat systems. The majority of Iraqi radar-guided SAMs were in the Baghdad area. Only a few SA-2s, -3s, -6s, and -8s were deployed in the KTO, and they were suppressed in the first few days. The Iraqi command

opted to protect Baghdad instead of the forces in the field. It was assessed that by Day 10, there was no longer any significant electronic warfare (EW) activity in the KTO. However, radar-guided SAMs were used sporadically at specific aircraft targets throughout the entire war, mostly on ballistic trajectories.

The proliferation of antiaircraft artillery (AAA) presented a continual threat to aircraft that came within its effective range. However, attacking aircraft could minimize this element of the air defense by remaining at high altitude (over 10,000 ft). Similarly, the threat from infrared (IR) guided missiles existed throughout the war, but the Iraqis had only a few effective modern Soviet-made IR SAMs and thus they were infrequently employed. The IR SAM threat in the KTO was also nullified by high-altitude tactics and the use of flares.

The air campaign against the Iraqi army in the KTO, a key Phase III objective, began at the outset of Desert Storm. As the campaign proceeded, it became more focused, and the number of sorties continued to grow as objectives from the other phases of the campaign were met. The number of attack (weapon employment) sorties flown in the KTO grew from approximately 400 sorties per day, divided between strategic air offensive targets in the KTO and the Iraqi Field Army, to over 1000 sorties per day, focused directly on the Iraqi ground forces The emphasis of the sorties directed against the Iraqi army in the KTO changed to exploit successful tactics and weapon systems.

The air operations for Phase IV of the campaign were planned to be air support for ground offensive operations. This phase of the operation was to be characterized by engagement and destruction of Iraqi units as they maneuvered to defend well ahead of coalition ground forces and the attack of elements of the Iraqi army attempting to retreat from Kuwait. Very little close air support was conducted or needed. A more accurate characterization of Phase IV would be coalition ground and air forces engaging different elements of the Iraqi army simultaneously in a joint campaign.

When additional air and land forces were deployed to the area of operation as a result of the president's decision to implement Phase II of Desert Shield in November 1990, coalition air forces were able to overlap the phases of the campaign.

The additional forces facilitated the conduct of parallel air warfare. In particular, the first three phases were conducted simultaneously. The ground offensive was delayed from the original plan. Bad weather and the need to divert forces to other priority missions such as the "Scud hunt" partly accounted for this delay. As in any operation, real world factors interfere with the best laid plans.

However, one has to be impressed with the correlation between actual operations and the original plan.

Organization of This Report

The conduct of the air campaign against the Iraqi army in the KTO is described in detail in the succeeding sections. Section 2 gives an overview of the coalition air and ground forces used in the KTO. Section 3 contains a chronology of the conduct of the air campaign over the 42 days of combat. Section 4 discusses the planning, control, and assessment of air operations against the Iraqi army. Section 5 reviews operational challenges that occurred in the course of the campaign. Section 6 contains a synopsis of the effectiveness of USAF aircraft and weapon systems against the Iraqi army. The final section analyzes the conduct of the campaign and the factors that contributed to the overwhelming defeat of the Iraqi army in the KTO.

2. The Joint Campaign to Defeat the Iraqi Field Army in the KTO

This section describes the air and land forces that operated in the KTO and the phases of the campaign against the Iraqi army. The joint campaign to expel Iraqi forces from the KTO was an unprecedented success. After 42 days of war, CENTCOM estimated that 38 divisions had been rendered combat-ineffective (the status of three others was unknown) and Kuwait was freed from Iraqi control. In the process, about 80 percent of the Iraqi tanks and artillery deployed in the KTO and about half of the armored personnel carriers were damaged, destroyed, or abandoned. Under the weight of continuous air attacks, over 50 percent of the Iraqi army deserted before the onset of the ground phase of the campaign.

The air campaign conducted by the coalition air forces in the KTO grew over the course of the campaign and changed in emphasis during the various phases of operations. A series of operational objectives constituted the air campaign in the KTO. These objectives were

- Suppression of air defenses
- Isolation of Iraqi forces in the KTO
- Destruction of Iraqi surface forces
- Support for coalition ground force offensive operations.

Air operations in support of these objectives overlapped in time, but they are distinctive in character.

The suppression of the air defenses consisted of lethal suppression of radar emitters with F-4G Wild Weasels; F/A-18s employing High-Speed Anti-Radiation Missiles (HARM) (AGM-88); jamming of radars with EF-111s and EA-6Bs; the disruption and destruction of the air defense command and control (C2) network with EC-130 Compass Call aircraft; and the destruction of critical C2 nodes principally with precision-guided munitions. This phase was essentially completed within the first few days. Following the initial intensive suppression of enemy air defenses (SEAD) campaign in the KTO, F-4Gs, EF-111s, EA-6Bs, and a Compass Call EC-130 were kept on station in the KTO continuously to provide threat warning and engage those emitters that operated

periodically. In addition to the organized SEAD effort, attack flights devised a series of tactics to discourage and suppress reactions by AAA sites.

Lines of communication (LOCs) into the KTO were under attack throughout this campaign to isolate the Iraqi forces in Kuwait. The objective of this interdiction campaign was to prevent resupply and reinforcement of the field army in Kuwait. This was accomplished by early concentrated attacks on the road and railroad bridges across the Tigris and Euphrates rivers. Follow-on attacks were conducted throughout the war to keep bridges out of commission. The bridge attacks were complemented by continued attacks on any traffic moving towards Kuwait. Joint Surveillance and Target Attack Radar System (STARS) and attack flights performing armed reconnaissance were used to find and attack vehicles attempting to resupply Iraqi forces in Kuwait. At the end of the war, of 54 fixed bridges across the two rivers, 40 were unusable, 10 were damaged, and 4 had been purposely left undamaged. In addition, 32 pontoon bridges constructed to circumvent the effects of the bridge attacks were also destroyed.

The destruction of the Iraqi army in the KTO before the ground offensive was a critical aspect of Operation Desert Storm. It is also unprecedented in modern warfare. A historical parallel to the air campaign to destroy the Iraqi army in the KTO might be the sieges of cities in the Middle Ages. Like an army in a fortified castle, the Iraqi forces sat hemmed in behind their modern moat by coalition ground forces, prevented from moving to the north and west by allied air interdiction and their own leaders. The Iraqi forces were subjected to constant bombardment from the air. Their only recourse was to dig in and to attempt to conceal and camouflage valuable assets.

A difference between this campaign and the sieges of the past is the size of the area and number of forces under siege. As in the past, the attackers found it difficult to know the status of the forces behind the fortifications. The measure of success of this campaign was that "the city fell" with minimal allied casualties.

The final phase of the air operations in the KTO was to support allied ground force operations. The objectives of this phase of the air campaign were achieved even faster than planned because of the success of the earlier phases. Just as the campaign objective to defeat the Iraqi Field Army in the KTO was greatly facilitated by successes in Phases I and II of the air campaign, the ground offensive was shortened and was conducted with minimum risk of life for the coalition ground forces because of the results achieved in Phase III of the air campaign.

Support of coalition ground force operations is a misnomer for this phase of Operation Desert Storm. A more appropriate characterization would be joint air

and land offensive operations against opposing ground force. With the objective of driving the Iraqi army from Kuwait and forcing surrender, coalition air and ground forces together engaged and defeated different elements of the Iraqi army, with the air forces focusing on Iraqi force elements well ahead of the rapidly advancing ground forces.

After the onset of coalition ground force operations, the air forces were principally used to engage the Iraqi army well in front of allied ground forces. In this role, air forces concentrated on any Iraqi forces that moved, including those positioning to counterattack and those retreating from Kuwait. Although many close support sorties were planned, few were flown in the four-day ground war because air forces were not needed in the close support role and were more effectively employed far forward of the attacking allied ground forces. An important reason for the use of air "well forward" was the reduction of the probability of fratricide. Additionally, the increasing range and lethality of direct-fire ground force weapons and attack helicopters has reduced the need for traditional "close" support.

Forces for the Campaign in the KTO

The campaign began in the early morning hours of January 17, 1991, but the character the campaign was to eventually take was shaped by the force disposition and planning that had occurred over a six-month period during Operation Desert Shield. The Iraqis began massing forces on the Kuwaiti border on July 17, 1990, immediately following the submission of grievances to the Arab League. Although this operation had to have been planned much earlier, the first force movements took place exactly six months before the onset of Desert Storm. To invade Kuwait, the Iraqis used six divisions with approximately 1200 tanks and armored personnel carriers. Between the invasion and October 1, the Iraqi forces in Kuwait had increased to 26 divisions with 5800 armored vehicles, and they had begun to dig in and build up defensive positions.

At the beginning of Desert Storm ground offensive (G-Day), the Iraqi ground forces had built up to a total of 41 divisions in the KTO. These divisions were arrayed in three echelons as depicted in Figure 2.1. The tactical echelon, consisting of infantry divisions organized into four corps, was arrayed along the Saudi Arabian border. The tactical echelon occupied fortified defensive positions with two trench lines, minefields, and berms along the border. These divisions possessed varying amounts of artillery to assist in the defense of their positions. Approximately eight mechanized, armor, and infantry divisions constituted the corps reserves for the tactical echelon. The density of Iraqi forces in the tactical

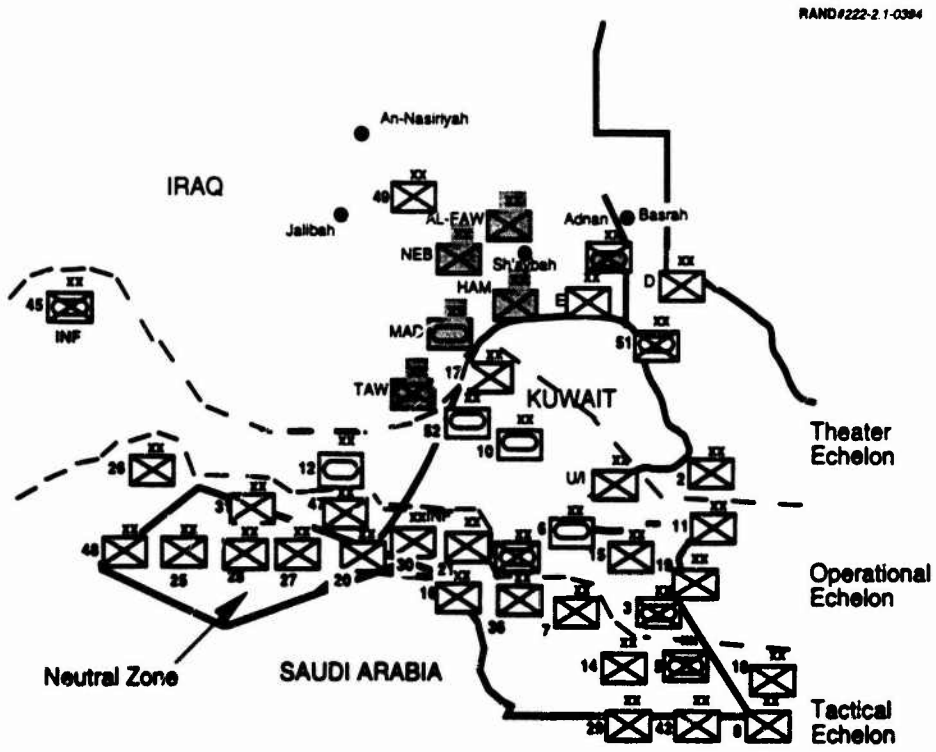


Figure 2.1—Disposition of Iraqi Ground Forces in the KTO on G-Day

echelon thinned out west of the Iraq/Kuwait/Saudi Arabian border. The defensive fortifications also became less formidable to the west.

The operational reserve forces consisting of 12 mechanized, armor, and infantry divisions were positioned in the middle of Kuwait and to the west into Iraq. Seven Republican Guard and four other divisions constituted the theater reserve forces and were located behind the operational echelon in Iraq adjacent to the Iraqi/Kuwaiti border.

These forces were protected from air attack by a network of SAMs and AAA. Presumably, this network also had air cover from the Iraqi Air Force, but, as we know, Iraqi airpower was totally ineffective during Desert Storm. The numbers and distribution of the SAM/AAA network in the KTO are shown in Figure 2.2. The network consisted of 200 radar-guided missiles, 3300 IR missiles, and 1200 AAA guns. This air defense array was relatively sparsely populated with radar-guided SAMs. Without air assets to cover the relatively static air defense network, the radar SAMs were vulnerable to defense suppression and were rendered largely ineffective. Once this happened, a sanctuary existed above 10,000 feet permitting coalition aircraft to attack the Iraqi ground forces in the

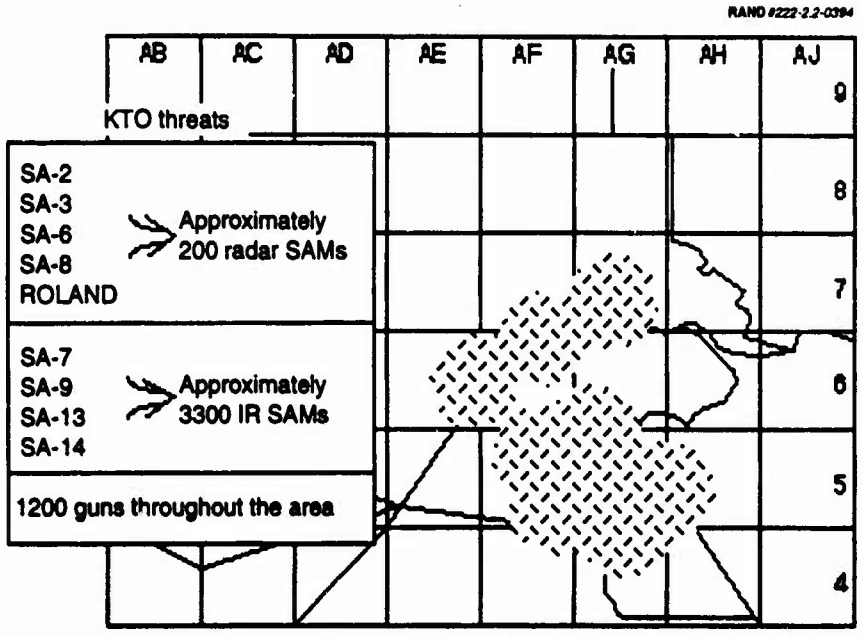


Figure 2.2—Iraqi Surface-to-Air Defenses in the KTO

KTO at will. The only options available to the Iraqi forces were concealment or dispersal.

Coalition Ground Forces

Five corps of coalition ground forces were arrayed along the Kuwait and Iraq borders before G-Day. Two U.S. corps, the XVIIIth Airborne and the VIIth, made the dramatic shift to the west in secrecy before the commencement of the final phase of the war against the Iraqi forces in the KTO. The coalition ground forces consisted of 6 armored divisions, 6 mechanized divisions, 2 airborne/assault infantry divisions, 2 marine expeditionary brigades, 6 brigade task forces, 2 light infantry regiments, 1 air defense artillery brigade, and 2 special forces groups. These coalition ground forces comprised 492,000 personnel. The disposition of the coalition ground forces before G-Day is shown in Figure 2.3.

Coalition Air Force

Coalition air forces consisting of more than 1900 fixed-wing combat and 1000 support fixed-wing aircraft from 10 nations began the air campaign against Iraq in Desert Storm. The number and type used in the offensive campaign against the Iraqi forces in the KTO grew during the war. In combat, every member of the

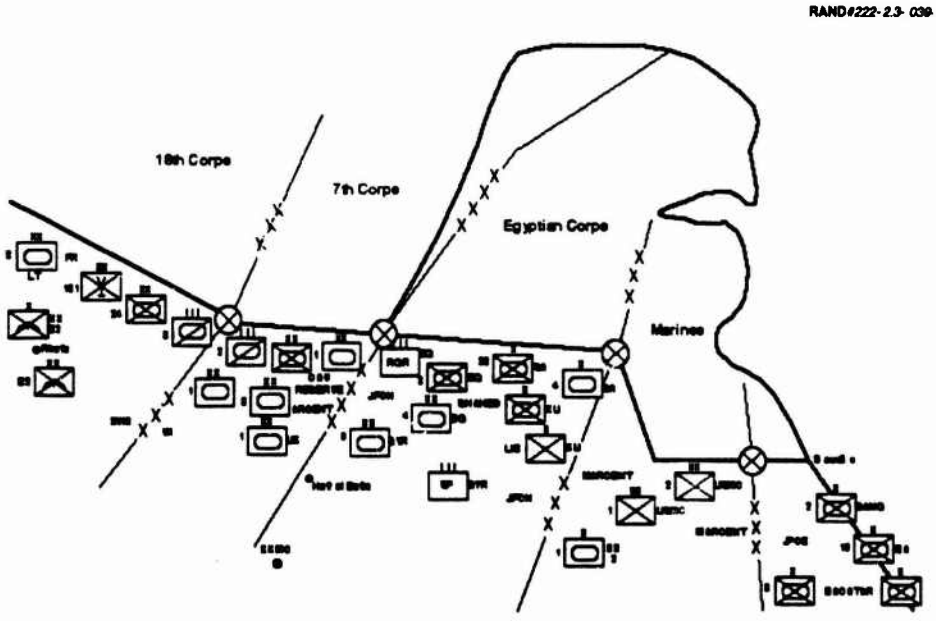


Figure 2.3—Disposition of Coalition Ground Forces—Pre H-Hour

team adds its own special contribution. Those listed above were the primary combat elements of the air assets used in the KTO campaign. The number and type of coalition aircraft employed in the KTO are shown in Table 2.1.

Table 2.1

Coalition Attack and Force Protection Aircraft for the KTO Campaign

USAF		USN		USMC		Other Coalition	
Attack						Saudi Arabia	
F-16	210	F/A-18	91	F/A-18	78	Tornado	48
F-15E	48	A-6	91	A-6	20	F-5	63
F-117	42	A-7	25	AV-8B	84	F-15	82
F-111F	64			OV-10	19	Kuwait	
B-52	65					A-4	19
A-10	132					Mirage F-1	15
AC-130	8					United Kingdom	
OA-10	12					Tornado	29
						Tornado Recce	6
Service total	583		207		186	Jaguar	12
Total attack	976					Buccaneer	8
						France	
Force Protection						Jaguar	24
F-15C	96	F-14	99	EA-6B	12	Mirage 2000	12
F-4G	48	EA-60	27			Mirage F-1	4
EF-111	20					Italy	
EC-130	8					Tornado	9
Service total	172		126		12	Canada	
Force protection total	310					CF-18	24
						Qatar	
						Mirage F-1	12
						Alpha	6
						Bahrain	
						F-1	12
Coalition total							385
Total aircraft	1671						

3. Development of the Campaign Against the Iraqi Forces in the KTO

The initial air campaign plan against the Iraqi forces in KTO was conceived as Phases II, III, and IV of the air operation in Operation Desert Storm. Phase II involved the suppression of enemy air defenses in the KTO, and Phase III involved isolation of Iraqi forces through interdiction of supplies and attacks on the LOCs and the destruction of Iraqi ground force units and assets in the KTO. Phase IV was conceived as air support for coalition ground forces during the ground war. Because of the early successes in suppressing the defenses, the completion of the air campaign was accelerated.

The character of the campaign in the KTO changed as increasingly effective tactics and procedures were developed and as the nature of the challenges was understood. This section describes the events and changing character of air operations in the KTO. While these operations were taking place, a related strategic air offensive operation was occurring throughout Iraq. The combination of strategic air offensive operations and the effort against the Iraqi army was critical in the ultimate accomplishment of coalition war aims in Desert Storm.

The exact number of sorties employed against the Iraqi army varied over the course of the campaign. Because of the flexibility of airpower, a flight that was tasked for one specific area or mission may have ultimately been employed somewhere else. The Master Attack Plan (MAP) in its original and amended versions shows each day's air operations as they were conceived by the planners. However, not all attack flights/missions were contained in the MAP. Specifically, it omits many of the sorties flown by the A-10s and Marine aircraft. The ATO is the formal tasking for the air campaign, but for flights that flew multiple sorties, only the first is shown in the body of the ATO. Mission Reports (MISREPs) provide an accurate accounting of the mission accomplishments of each flight, but we do not have a complete inventory of MISREPs. Sortie recaps show the number of sorties flown for each aircraft type by day, but the recaps do not tell where the sorties went and what they did.

After comparing the MAP, Air Tasking Order (ATO), available MISREPs, and sortie recaps, we used an accounting procedure to provide a picture of the evolution and conduct of the campaign. We used the MAP, amended with the

daily change sheets, to give a broad picture of each day's operations in the KTO. Where questions existed in the MAP, the specific section of the ATO was checked. It is not surprising that we found fairly close correlation between the ATO and the MAP. Because of the difficulty of accounting for "turn" flights for the A-10s, the number of sorties for A-10s shown in the following discussion are taken from the sortie recaps. AV-8B missions were seldom included in the MAP. Also, there is poor correlation between AV-8B tasking in the ATO and the number of sorties flown. Therefore, the levels of effort for the AV-8Bs shown in this section are compiled from the sortie recaps.

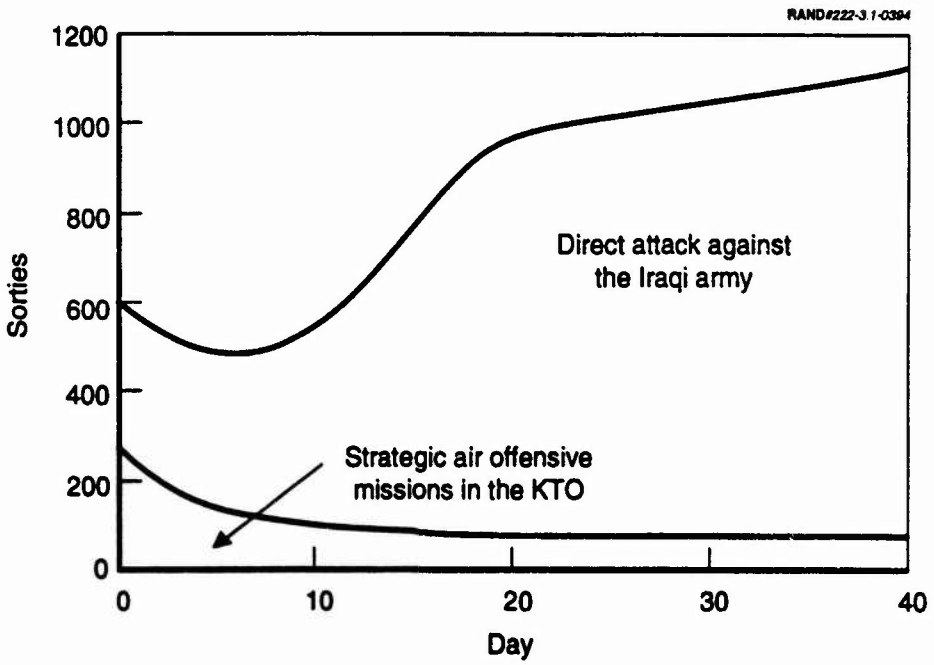
The resulting discussion of the air campaign in the KTO was derived from the documents described above and from interviews with planners and participating aircrews. It presents a fairly accurate, though not exact, picture of the operations against the Iraqi army in the KTO.

Overview of Air Operations in the KTO

Forces were employed directly against Iraqi ground forces from the beginning of the war. On the first day of the air campaign, the majority of planned sorties in the KTO were employed against strategic targets ranging from airfields to oil facilities to Scud missile launchers. As the campaign progressed, the emphasis of the air campaign in the KTO shifted to the direct attacks of Iraqi ground force assets and supplies. The number of sorties and types of aircraft used for this phase of the campaign increased.

Toward the end of Phase III and through the ground war, over 1000 sorties daily were flown in direct attacks on Iraqi ground forces and supplies in the KTO. Figure 3.1 shows the relationship of the effort of the coalition air forces in the KTO. By the third day of the air campaign, the number of sorties employed against strategic targets in the KTO dropped below 150. When the battle of Khafji began on January 29, the number of sorties planned for strategic targets in the KTO dropped below 100 and rose above that figure only twice for the remainder of the war. The weight of effort was shifted to Iraqi ground forces.

Next we present a chronology of events that will describe the evolution of the campaign against Iraqi ground forces. The first three days of the air campaign in Operation Desert Storm were the "scripted war." This phase was initially planned and conceived in August and the plan was refined until the onset of Desert Storm.



SOURCES: MAP, ATO, and sortie recaps.

Figure 3.1—Allocation of Sorties Flown in the KTO

The Scripted War (Days 1–3)

Approximately 250 fixed-wing aircraft sorties and 8 Tomahawk Land-Attack Missiles (TLAMs) were employed against strategic offensive targets in the KTO on the first day. The effort against the Iraqi ground forces on the first day began with about 400 sorties. One-hundred and forty-four A-10s and OA-10s flew multiple sorties against preplanned artillery targets and from ground alert. On the first day, 294 A-10 sorties were flown, making it the heaviest A-10 flying day of the war. Additionally, 20 AV-8B close air support sorties were flown in the U.S. Marines Central Command (MARCENT) sector. Twenty-four F-16s were targeted against the Republican Guards, and 16 F-16s attacked Iraqi ground force command posts. Eight B-52s attacked Republican Guard positions to open the campaign. To isolate the Iraqi forces in the KTO, 20 sorties consisting of F/A-18s, A-6s, and F-15Es attacked bridges along the LOCs to Kuwait on the first day.

On the second day of the scripted campaign, 130 F-16, 24 F-18, and 9 B-52 sorties were tasked to attack Republican Guard positions. Across the tactical echelon, 178 A-10s, 36 AV-8Bs, and 3 AC-130 sorties were flown. On the last day of the three-day scripted war, the B-52 effort increased to 25 sorties against the

Republican Guard positions. From Day 3 until the week before the ground war began, the number of B-52 sorties planned and flown against the Republican Guard divisions ranged between 25 and 35 sorties daily. On the third day, F-16Ls Low-Altitude Navigation and Targeting Infrared at Night (LANTIRN) and F-15Es began night operations against Iraqi forces, using their onboard sensors to acquire targets. Thirty-five percent of the sorties flown by coalition air forces in the war were flown at night. This is the first time massed airpower has been used on a continuous basis against an opposing field army at night.

Building the Tempo (Days 4–15)

The character of the air campaign against the Iraqi army in the KTO took shape and increased in the level of effort from January 20 until February 1. The level of effort in the KTO was reduced for the first few days of this period because of bad weather, the shift from a scripted operation to planning large-scale operations on a continuous basis, and the need to shift sorties to the high-priority Scud hunting mission.

Air operations against the Iraqi forces in Kuwait shifted from the scripted campaign on January 20. The number of sorties flown on this day in the KTO was the lowest of the entire war. The weather was bad, and the continuity of effort dropped in the transition of the planning process. The bulk of the flying effort in the KTO on Day 4 involved 30 A-10 sorties employed in joint operations with AC-130 gunships.

The next day (January 20), "kill boxes" were introduced in the ATO as a planning device to control the weight and distribution of operations against the Iraqi ground forces in the KTO. This system had been laid out in the early days of Desert Shield. The kill box grid consisted of 30 minutes of latitude by 30 minutes of longitude as shown in Figure 3.2. The kill box grid was further subdivided into quarters (NE, SE, SW, and NW). By tasking an attack flight into a specific area such as kill box AF6, the pilots were able to focus pre-mission study and planning into an area that was fairly easy to picture and assimilate. Flights could be, and were, diverted to other kill boxes (target sets). The kill box grid proved to be useful for planning the weight and distribution of the air effort and facilitated pre-mission planning. In addition, the use of the kill boxes enabled some deconfliction of air traffic in the KTO and southern Iraq.

The Scud hunt began in earnest on January 22, Day 6, another day of bad weather that limited the number of effective sorties. On the first large Scud hunt day, 40 A-10s, 40 F-16s with LANTIRN, and 32 A-6s were tasked to search out

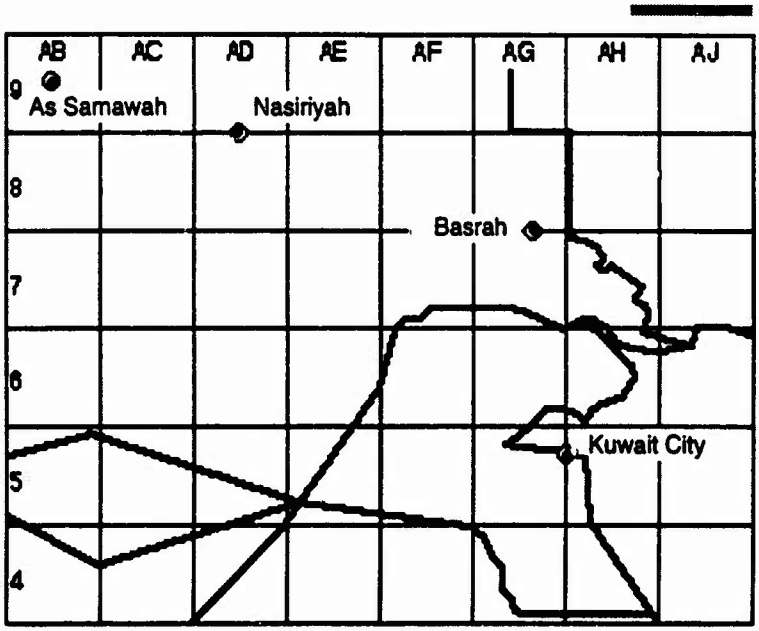


Figure 3.2—Diagram of the Kill Boxes

and destroy Scuds. Eventually, the Scud hunt mission was conducted mainly by A-10s in the day and F-15Es and LANTIRN-equipped F-16s at night. Joint STARS was used to cue F-16s in the eastern Scud launch area. This operation had an indirect effect on the campaign against the Iraqi army in Kuwait. From D+6 until a week before the ground war began, 30 to 40 A-10 sorties were tasked daily to search for and destroy Scuds in Iraq, and approximately 10 A-10s were maintained in the west at Al Jouf on a rotating basis for this mission. This mission accounted for approximately 20 percent of the A-10 sorties available, reducing the level of effort against the Iraqi army.

Day 7 was a relatively light flying day within the KTO. Two-hundred and forty-seven A-10 sorties and 46 AV-8B sorties were flown along with 60 F-16 and F-18 sorties against the Republican Guard divisions. A notable event on this day was the detection by Joint STARS of a moving Iraqi column with 72 armored vehicles. Two A-10s and an AC-130 were diverted to engage this column. When they finished, 58 of the 72 armored vehicles in the column were reported destroyed.

The next day, January 24, was the first day that F-15Es were used in force against the Iraqi army. Sixteen F-15Es armed with CBU-87 antiarmor cluster bombs were tasked against Republican Guard positions. The pattern of employment for the A-10 aircraft operating in the KTO appeared for the first time in the MAP and the ATO on this day. A-10 operations were divided into four-ship flights for

daytime attack sorties and two-ship flights at night. The ratio of daytime to nighttime sorties was approximately 2 to 1, and this ratio remained relatively constant for the rest of the war. About 10 percent of planned A-10 operations was set aside on ground alert for close air support (CAS) and search and rescue.

On January 25, there was a noticeable increase in the level of effort against Iraqi ground forces; over 600 sorties were tasked to attack the Iraqi forces in the KTO. On this day, the number of attack sorties flown by Kuwaiti A-4s and Mirage F-1s,[1] French Jaguars, British and Italian Tornados, and Saudi Tornados and F-5s in the KTO reached almost 100 per day. This level of effort by aircraft from non-U.S. coalition air forces remained about the same for the remainder of the war. Later in the campaign, this mix of coalition aircraft was joined by Canadian F-18s, French Mirage 2000s, and Qatari Alpha Jets.

Activities on January 26 were planned to focus on the Republican Guard positions. For the first time, Marine AV-8B sorties appeared in the ATO (AV-8B operations were consistently omitted in the MAP until the deception operations began on Faylaka Island a week before G-Day). Before January 26, the AV-8B force principally sat on CAS alert, averaging 35 sorties per day (slightly over 0.5 sorties per day per aircraft). Until Day 10, the AV-8s seldom exceeded 50 sorties a day. The tasking for AV-8s was set at a constant 104 sorties per day in the ATO (except for Day 41) for the remainder of the war. After the AV-8Bs began appearing in the ATO, their sorties jumped to an average of 68 sorties per day for the next 10 days, and then they increased their effort to over 90 sorties flown per day. The AV-8B force was essentially held in reserve for the first three weeks of the war.

On January 27, the oil manifolds that controlled the flow of oil into the Arabian Gulf were shut down. The flow, which created a massive oil slick, had been started by the Iraqis three days earlier. F-111Fs employing GBU-15 bombs were used to stop this environmental catastrophe. Less noticed, but important in terms of combat effectiveness, was the initiation of explicit tasking for F-15Es and Joint STARS to locate and destroy targets in the KTO. From this point on, F-15Es, and later LANTIRN-equipped F-16s, were tasked to work directly with Joint STARS each night. On the next day, specific procedures for Joint STARS targeting of Iraqi ground force targets were published in the Special Instructions (SPINS) section of the daily Airspace Coordination Order (ACO).

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[1] Because the Iraqi air force also operated Mirage F-1s, these aircraft were not used until air superiority was achieved. After that, they were paired with A-4 and F-5s in the scenario flight to facilitate identification.

The process of incorporating Joint STARS targeting into daily operations is a model of the tactical innovation process during Desert Storm. A new tactic or procedure would be tried out for a few days with selected aircrews. If successful, it would be formally incorporated into the MAP/ATO at a low level of effort. Then the level of effort would be increased and formal operating procedures (SPINS) published. This process for introducing new tactics and procedures was quite rapid in comparison to the process used in past conflicts. It took less than a week from conception of new tactics to maturity.

The battle of Khafji began on January 29 when an Iraqi armored column advanced into Saudi Arabia. Attention was focused on the action between the advancing Iraqis and the Saudi and Marine forces that were defending this coastal town. The armored column that was engaged by Saudi forces, U.S. Marines, and the coalition air forces was one of three Iraqi units engaged in this battle. Two other Iraqi divisions were detected on the move within Kuwait at the same time. They were engaged and stopped by coalition air forces before coming in contact with coalition ground forces. Over 800 sorties were flown against the Iraqi ground forces on the first day of the battle.

With the ability to see enemy movements deep into Iraqi-held territory with Joint STARS and overhead reconnaissance, coalition air forces were able to constitute a flexible and responsive theater reserve force that could mass quickly anywhere in the KTO. To augment the night attack forces, F-16Ls (LANTIRN-equipped) were tasked for the first time for direct Joint STARS targeting.

The character of the coalition air campaign was taking shape by the end of January, two weeks into the war. By this time, standard force packages and procedures for defense suppression in the KTO had evolved to the point where they had become relatively stable. At the beginning of the campaign, selected force packages were escorted by defense suppression aircraft. Then defense suppression assets were concentrated over specific areas such as Republican Guard positions. By the end of January, F-4Gs, EF-111Fs, EA-6Bs, and Compass Call maintained area coverage over the KTO. A typical daily commitment for defense suppression support in the KTO was 22 F-4Gs, 6 EF-111s, 3 to 6 EA-6Bs, and 4 EC-130 Compass Call aircraft. Periodically, A-10s or F-16s would be teamed with the Wild Weasels for SAM removal or SAM patrol missions.

Improving the Effectiveness in Attacking Iraqi Divisions (Days 16–29)

As February approached, the U.S. public and the world wanted to know when the war would be over. Although the accomplishments to this point were remarkable, the end was not yet close. Battle Damage Assessment (BDA) reports were publicly reported, and there was an increasing awareness of the discrepancies in BDA. Different agencies produced independent estimates of the number of artillery and armored vehicles destroyed, and they varied widely. It will probably never be possible to distinguish how many targets were destroyed. U.S. Air Force Central Command (CENTAF) planners and the participating fighter wings were convinced that they were more effective than the damage estimates indicated. BDA remains an emotional topic. The debates about BDA and the building pressure to conclude the war motivated CENTAF planners to find means to increase the rate at which the Iraqi army was being destroyed.

There was a noticeable improvement in the effectiveness of the coalition air campaign in the KTO from the beginning of February until the end of the war. Several tactical innovations were introduced in early February. F-16s undertook the Killer Scout mission, a role similar to that of the fast FACs in Southeast Asia 20 years earlier. F-111Fs, F-15Es, and A-6Es were used for tank plinking and for launching laser-guided bombs against armored vehicles and artillery. The increased effectiveness after February 1 must also be attributed to the fact that aircrews became increasingly familiar with the mission, the threat, and the environment. This familiarity produced improved results. It is not uncommon to hear an aircrew member say "After three or four missions in the same area, I really began to know what I was doing."

The Killer Scouts began operations on February 1. A Killer Scout mission consisted of an F-16, or F/A-18D, two-ship flights, which operated throughout daylight hours in a specified kill box. The boxes where the scouts generally operated were north of 29°30′N, across the center of Kuwait. On February 1, four F-16s operating in two flights of two tested the Killer Scout concept. Twelve Killer Scouts were tasked in the MAP three days later. The number of Killer Scouts used each day quickly grew to 24, and later to over 40 sorties per day.

The flow of Killer Scout flights was orchestrated to keep one two-ship flight in a designated kill box constantly during daylight hours. Three two-ship flights were tasked for each time period in a box: At any one time, two aircraft would be on station; two en route to, or from, a tanker; and two aircraft would be refueling.

The Killer Scout flights would arrive on station about 15 minutes before the first attack flights were expected. They would have a list of scheduled attack flights and the preplanned targets for each flight. The Killer Scouts would observe the specified targets and the kill box area for signs of enemy activity. When the attack flights arrived, they would be directed by the Killer Scouts to the most lucrative target in the area.

With the introduction of Killer Scouts, the level of activity picked up during the first week in February. On February 2, 66 F-15E sorties were tasked in the KTO and 52 F-15E sorties were used on the following day. The first of 11 BLU-82s were dropped on February 3. The BLU-82s were 15,000 lb bombs dropped from the rear of an MC-130. These weapons were to remove minefields. However, it was discovered that they had a significant psychological effect on Iraqi ground units. It has been reported that a British special forces team operating behind Iraqi lines mistook a BLU-82 explosion for a small nuclear explosion. BLU-82 drops were accompanied with psyops leaflet drops.

Tank plinking was first tested on February 5. Tank plinking was the engagement of revetted Iraqi armored vehicles with GBU-12 laser-guided bombs. This tactic was an innovative response to the need to reduce the combat power of Iraqi ground forces in the KTO at a quantifiable rate. This tactic was possible because after sunset Iraqi tanks and vehicles cooled at a different rate than the sand bunkers that surrounded them; therefore, vehicles were detectable by the FLIR pod on the F-111F and other aircraft. Once detected, the static armored vehicle could be designated with a laser to guide the GBU-12 bombs.

The introduction of the process of tank plinking was similar to that used by Killer Scouts. F-111Fs tried tank plinking on February 5, and the mission became a permanent feature of the MAP/ATO four days later on 8 February. About a week later, A-6Es and F-15Es also began to be used for tank plinking. Against a static ground force, tank plinking was a very successful tactic. On one notable mission about a week after the tactic was introduced, a two-ship flight of F-15Es carrying a total of 16 LGBs reported the destruction of 16 armored vehicles on a single mission—one tank kill for each bomb dropped.

Because of the success of precision-guided weapons, Royal Air Force Buccaneer aircraft were deployed to the theater while the war was in progress. They began operations as laser-designator aircraft for British Tornados on February 3. For approximately two weeks, Bucccaneer/Tornado teams were the primary aircraft used in the bridge campaign to isolate the Iraqi army in the KTO. They were also used against aircraft shelters on airbases in southern Iraq and Kuwait. Their use

on LGB missions permitted the employment of the more capable F-111Fs, F-15Es, and A-6Es for tank plinking.

After the first week in February, a relatively stable distribution plan for the large number of F-16 attack sorties was reflected in the MAP and the ATO. The weight of the F-16 force effort was distributed between eastern and western sets of kill boxes to apply combat power methodically to different Iraqi divisions. On February 12, CINCCENT issued guidance that when an Iraqi division was attrited to 50 percent of its assessed combat power, it would no longer be attacked. When this goal was reached for an individual division, the weight of effort would shift to other units in the KTO. Finally, to increase the sortie rate of the F-16 force, CINCCENT began quick-turning sorties out of King Khalid Military City in early February. By staging sorties out of King Khalid, F-16s could fly three sorties a day carrying four 2000 lb bombs without requiring air refueling.

Killer Scouts, tank plinking, concentrated heavy bomber missions, and a maturing plan to distribute the attack effort produced noticeable effects by mid-February. The Iraqi army was progressively losing assets and the will to fight. New procedures for the conduct of air support of ground forces emphasizing the importance of avoiding fratricide during offensive operations were published in the Airspace Coordination Order on 15 February. The countdown to G-Day was under way.

Isolating the Iraqi Army—Attacking the Bridges

A dedicated effort was conducted against the bridges along the Tigris and Euphrates rivers. The destruction of these bridges was an important step in stopping the flow of supplies to the Iraqi forces in the KTO. At the outset of the war, there were 54 railroad and highway bridges across these rivers. Forty-one of these bridges had been destroyed by the end of the war and four were damaged. Additionally, 32 pontoon bridges erected by the Iraqis to offset the effects of the bridge campaign were also destroyed. As a result of the bridge campaign and the interdiction sorties that attacked the traffic that was constrained because of the destruction to the bridges, CINCCENT analysts assessed that the Iraqi army in the KTO was unable to conduct offensive actions after 10 days and could not conduct any effective combat actions after three weeks.

The effort against the bridges is similar in its evolution to the larger Desert Storm air campaign. The aircraft used and the level of effort changed over time. These

changes were made to find the most effective combinations and to allow the use of more capable elements of the coalition air forces where they were needed most.

For the first four weeks of the campaign, an average of 25 sorties per day were tasked for bridge attacks. The level of effort was reduced when the coalition effort shifted to final preparations for G-Day (February 13). For two days, no bridge attack missions were tasked. From February 15 until the last day of the war, the average number of sorties flown to attack the bridges decreased to about 12 per day. By this time, most of the bridges had been dropped, and the remaining job was to disrupt repairs and destroy the pontoon bridges that the Iraqis were erecting to attempt to sustain a minimal rate of flow into the KTO. On the last day of the war, a combination of F/A-18s, A-6s, and B-52s mined the bridges and routes out of the KTO to slow the exodus of Iraqi forces across the bridges.

The composition of the force used in the mini-campaign against the bridges evolved over time. For the first 12 days, the F/A-18s and A-6s composed the bulk of the force tasked to attack bridges. These aircraft flew 72 percent of the bridge attack sorties during this period. After the first two weeks, these aircraft were only used sporadically and in small numbers for this mission. The F/A-18s did not have LGBs and were not very effective. Hitting a bridge is very difficult without precision munitions. F-117s and F-111Fs employing LGBs were used on two days (D+2 and D+8) during the initial period.

For four days—from January 29 to February 1 (D+13 to D+16)—F-117s and F-111Fs with LGBs were the only aircraft tasked to attack bridges. Beginning on January 29 through the end of the war, an average of 6 F-111F missions were flown daily against the bridges.

Beginning on February 2, the Royal Air Force (RAF) assumed responsibility for a large share of the bridge campaign. Buccaneer aircraft had deployed to the theater after the start of the war. These older aircraft had laser designators. They were used in conjunction with U.K. Tornados to attack bridges for an 11-day period at the beginning of February. The Buccaneer/Tornado team was tasked for about 15 sorties daily over this period (60 percent of the planned effort). At the end of the period, Tornados with Thermal Imaging Airborne Laser Designator (TIALD) pods did their own designating. The RAF was very resourceful in finding effective means to contribute to the campaign.

After February 13, the level of effort dedicated to the bridge campaign dropped to an average of 12 missions per day. Evidently, what was needed after this time was a policing force to take care of any repair and pontoon bridge operations.

About 6 F-111Fs and a mixture of other available aircraft were used to do this job until the end of the war.

Precision-guided munitions were the key to a successful bridge campaign. It is interesting to note that the total number of sorties used to interdict 54 road/rail bridges and 32 pontoon bridges is almost equal to the 857 sorties flown unsuccessfully using "dumb" bombs against the Thanh Hoa bridge in the Vietnam War. In Desert Storm, fewer than 1000 sorties were used to drop all the bridges along 200 miles of the Tigris and Euphrates rivers.

Final Preparation for the Ground War (Days 30 to 38)

As G-Day approached, sorties committed to the KTO continued to increase, and operations took on a slightly different character. On February 15, concentrated attacks began on the defensive positions and artillery along the front. Fourteen F-117s were used to attack the valves and manifolds that controlled the flow of fuel into the defensive fire trenches. Sixty-four F-16s were tasked to attack antiaircraft artillery and surface-to-air missile sites in southern Kuwait to suppress attacks on the first massed cross-border operations with U.S. Army AH-64 attack helicopters since the attack on the early warning radar sites in southern Iran on the first day of the war.

B-52s were first tasked to attack Iraqi fortifications along the border on February 17. The use of B-52s on breaching targets continued every day until the ground war began. In addition to the B-52 missions, Tornados attacked the trenches, F-111Fs struck the berms, AH-64s hit bunkers, and later Marine fixed-wing aviation delivered napalm on the trenches for three days preceding the ground war.

By February 17, the level of A-10 activity against Scud launchers began to decrease. A-10s assigned to the Scud hunting mission in the KTO were given an alternative task of battlefield reconnaissance. This change in mission apparently reflected the decrease in Scud activity and the growing importance of ground force targets.

Tight control procedures for the employment of CBU-89 air-delivered mines were introduced on February 18. This measure was necessary to identify mined areas for the advancing coalition ground forces.

Between February 20 and G-Day, Marine AV-8Bs and later F-16s, F-18s, B-52s, and the battleship *Missouri* attacked Faylaka Island. These attacks were part of

the deception plan to convince the Iraqis that an amphibious landing was imminent.

For 9 days before G-Day, coalition air forces prepared the way for the final air-land thrust to eject the Iraqi army from Kuwait. The methodical attrition of tanks, APCs, and artillery continued with increasing effectiveness. Fortifications and defensive positions along the front were taken down under the weight of continued attack. This well-planned process made the Iraqi army ready for the final phase.

The Final Phase—G-Day Until the End

The final phase of the campaign against the Iraqi forces in the KTO, the ground war, is frequently pictured with tanks moving across the desert in the "Hail Mary" maneuver. Although coalition ground force operations were extraordinary, the ground forces were part of a larger joint battle involving coalition air and land forces. Coalition ground forces advanced rapidly across Kuwait and southern Iraq engaging and defeating the Iraqi army, and coalition air forces engaged Iraqi land forces moving ahead of the rapidly advancing ground units.

To control areas of responsibilities for air and land forces, phased Fire Support Coordination Lines (FSCLs) were used. These FSCLs were published in advance in the ACO. Because of the pace of the land battle and the rate of advance, coalition ground forces often overran the preplanned FSCLs. Attack flights, forward air controllers (FACs), and the Killer Scouts received updates on the FSCL locations through the Airborne Command and Control Center (ABCCC) and the Corps Air Support Operations Centers (ASOCs). Updating the FSCL in this fluid situation was a problem in this phase. Generally, air support for ground forces was conducted beyond the FSCLs, more than 8 km from friendly troop positions. The rule of thumb for coalition air forces was, "If in doubt, don't drop."

A large CAS effort had been anticipated during the ground war, but the principal USAF CAS aircraft, the A-10, was not needed to the extent anticipated during this phase. The A-10s flew about the same number of sorties after coalition ground force operations commenced as they had during the rest of the campaign. Because of the depletion of the assets and fighting will of the Iraqis and the effectiveness of coalition ground forces, the anticipated surge in CAS requirements did not occur. The Marine AV-8Bs, however, doubled their optempo beginning the day before G-Day and for the first three days of coalition ground force operations. The average number of sorties reported flown by the

AV-8Bs from February 15 until the day before the ground war was 74. For the four days of ground action in the MARCENT sector, the AV-8Bs flew an average of 149 sorties per day.

On the night of February 25/26, the day before the cease-fire, Joint STARS detected the Iraqis fleeing north from Kuwait City toward Basra. F-15Es had just recovered from a mission and were directed by the Tactical Air Control Center (TACC) to quick-turn and engage the retreating forces. Despite low clouds, smoke, and night conditions, these aircraft successfully attacked the leading and trailing elements of the columns with CBU-87s. Once the columns were stopped, waves of coalition aircraft attacked the column, creating the telling pictures of destruction along the roads to Iraq.

The story of the campaign against the Iraqi forces in the KTO is one of building pressure and tactical innovation. The nature of the campaign differed from the way it was envisioned at the outset. Once air superiority was achieved, Iraqi forces were immobilized. The challenge then became one of detecting and engaging 43 divisions spread across Kuwait and southern Iraq. The need to accomplish the task within predetermined time limits propelled the drive to find the most effective means for accomplishing the task. The rate of success increased with time. In the end, the fourth largest army in the world was demoralized and utterly defeated.

4. Planning, Control, and Assessment of the Campaign in the KTO

The outcome of the campaign against the Iraqi army in the KTO was a direct product of the planning and battle control process and systems. The air operations in the KTO (and throughout the Gulf region) were executed through three overlapping types of control:

- Force control established the weight of effort and provided the structure and allocated the assets for large-scale air operations. The means of force control was a joint allocation and planning process. Because of the sheer scope of air operations, the planning/force control process took place well in advance of the time operations were actually conducted.
- Battle control adjusted the weight of effort in response to the changing tactical situation while operations were in progress.
- Engagement control directed specific missions to specific targets and assisted in the target acquisition and engagement process.

The planning process functioned in conjunction with an imperfect assessment system to focus the application of airpower throughout the course of the campaign. Because the planning process for a campaign of this scale must inherently take place well in advance of mission execution and because the dynamic nature of battlefield targets places a premium on timely execution, a mission and engagment control system is necessary to concentrate the weight of the attacks in areas where lucrative targets present themselves. Assessment of results is needed both for planning and for battle control.

This section examines the functioning and interactions of the planning, control, and assessment systems for Operation Desert Storm in the campaign against the Iraqi ground forces in the KTO. Just as the campaign against the Iraqi ground forces evolved over time, the planning, control, and assessment systems were modified and matured throughout the course of the campaign. One of the most impressive aspects of the campaign and modern warfare is that innovations in planning and battlefield control were developed, tested, and implemented over a relatively short period. Planning for the campaign against the Iraqi forces in Kuwait was a very detailed and complex process. The sheer magnitude of planning for up to 1000 attack sorties against an army spread over 300,000 square

miles is formidable. In this environment, an air traffic and airspace control system had to be organized and operated. Adding to the complexity was the need to integrate air refueling, defense suppression, electronic warfare, air defense and surveillance, and reconnaissance assets. This air campaign also had to be integrated with the priorities and scheme of maneuvers of ground force commanders.

Campaign Planning for Air Operations in the KTO

The control planning process was overlapping and iterative. It began two days before the time of execution and culminated in an ATO, which was transmitted to the operational units the day before missions were to be flown. The ATO was a lengthy computerized plan that specified all aspects of the air campaign from airspace control to the targets and procedures for individual flights every day. It specified mission details for almost all fixed-wing coalition aircraft, providing the structure for the campaign. The ATO also contained an ACO, which organized airspace use throughout the theater, and a set of SPINs, which provided changes to operational procedures for the conduct of the campaign. The ATO was the product of the integrated planning process and was based upon the guidance of the joint commanders.

The portion of the ATO directed against the Iraqi ground forces in the KTO involved more elements of the joint planning process than the strategic air offensive campaign. The commanders of the coalition corps submitted target nominations for CAS and air interdiction (AI) each day. These target nominations were consolidated by the respective component commands (U.S. Army Central Command (ARCENT), MARCENT, and coalition commanders), and were then given to the Deputy Commander in Chief, U.S. Central Command (CENTCOM) for integration and to ensure that priorities were consolidated in accordance with CENTCOM guidance to achieve the desired effect. Then the list was given to the Joint Force Air Component Commander (JFACC) for incorporation into the MAP. The MAP was reviewed, modified, and approved by CINCCENT each day. The MAP provided definitive guidance for the ATO. The MAP was the campaign plan, and the ATO was the order that directed its execution. Concurrent planning on different portions of the campaign plan each day took place in the "Black Hole" and in the TACC. Responsibilities for planning the air campaign shifted throughout the course of the campaign.

The layered approval process resulted in modification to the target lists submitted by the individual corps commanders. This modification was done to conform to a theater-level campaign plan and resulted in some frustration and

dissatisfaction among corps commanders because not all their specific requests were immediately satisfied.

A key objective for the first three weeks was the progressive destruction of the Republican Guard divisions. Then, specific emphasis was given to attriting all Iraqi divisions to the 50 percent level. Responsibility for assessing the attrition levels in the individual Iraqi divisions was given to ARCENT. Ten days before the ground campaign, a portion of the coalition air forces was targeted against the defensive fortifications, barriers, and artillery along the border. When the ground campaign began, coalition air forces were tasked to support offensive ground operations. Because of the speed of the ground operation and the effects of the earlier air campaign, the level of support for advancing coalition ground forces was far less than anticipated.

The plan for the air campaign in the KTO provided structure and a basis for unit mission planning. The grid (kill box) structure shown in the previous section outlines the framework for organization. Figure 4.1 shows the "kill boxes." Before the beginning of the ground war, the FSCL was located near 29°30'N. South of this line, permission by the ground commander was required to conduct air attacks. This permission was provided to attack aircraft by FACs and the ASOCs. Beyond 29°30'N extending up to 30°30'N was the Killer Scout area of operations. The ABCCC and Joint STARS were also used to assist attacks in this band. North of 30°30'N latitude was the flight lead control interdiction area.[1] Generally, flights coordinated with AWACS when operating in this area. The responsibility for control of each zone varied over time, and changes were provided in the SPINS in the ATO.

After coalition ground force operations began, the same concept was used; however, the areas of responsibility changed with the progress of the coalition ground forces. Inside the FSCL, permission from the ground commander was required before attacks could be conducted. With the greater-than-anticipated rates of advance, the FSCL was pushed out farther and farther in front of the ground forces. Killer Scouts acted as a buffer between CAS and AI. They had responsibility for the area beginning at the FSCL and extending 30 nmi beyond. Beyond the Killer Scout zone, flight leaders conducted interdiction as before.

A JFACC objective of the planning process was to task sorties against each target nominated by the ground commander. Because of competing demands for critical assets, this was not always possible at the time requested. CINCENT's guidance also constrained accomplishment of this goal. For example, after an

[1]The demarcation at 30°30'N latitude was called the "Horner Line."

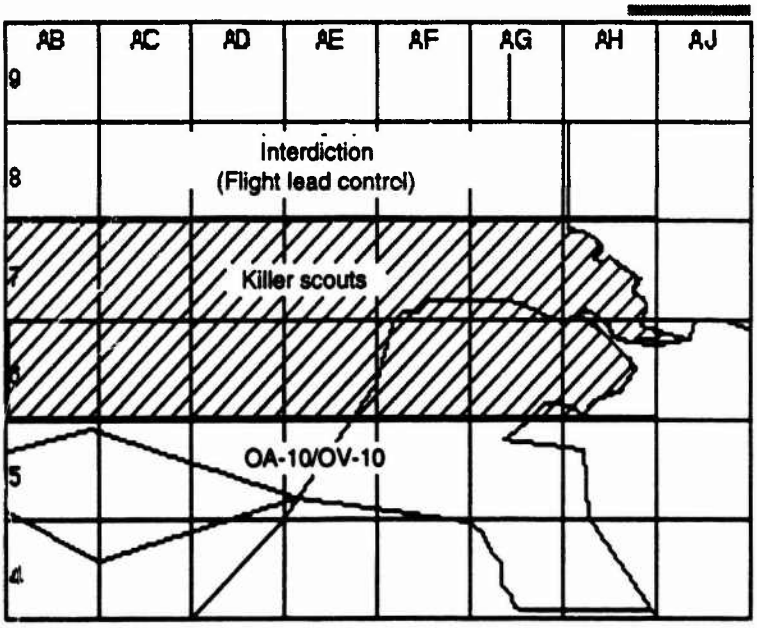

Figure 4.1—Operational Areas for the Air Campaign in the KTO

Iraqi division was assessed to have been attrited below 50 percent, attacks moved to another area even if the opposing coalition ground commander requested a target in that area.

Each flight was assigned a target or a kill box. In addition, flights were given a backup target in case the primary one could not be attacked. Instructions were provided in the SPINS that flights tasked for air interdiction missions could be diverted to close air support. Similarly, CAS missions could be diverted to interdiction by a designated control agency.

The output of the joint planning process at the theater level was the ATO. The ATO was amplified through the daily, weekly, and monthly ACO and SPINS. At the unit level, it was a time-consuming task to extract information pertaining to an individual mission from the ATO and to combine it with the latest available intelligence information on the target and threats. The operational units (wings) involved in Operation Desert Storm developed informal and formal procedures to accomplish this task.

At the wing level, mission planning was principally accomplished by a designated mission planning cell, whose function was to extract information from the ATO pertaining to the unit's mission for the following day. The information extracted was combined with the intelligence information on the tasked target areas available at the wing, or accessible through distributed

intelligence systems such as Sentinel Byte and Constant Source. Some wings kept extensive databases on targets in the "kill boxes." This information was consolidated and updated through mass debriefings.

The mission planning cells were generally formed from a cadre at the wing level consisting of members of the weapons and tactics section and intelligence. The wing mission planning cell was augmented by two "highly qualified" flight leaders from each squadron on a rotating basis. Each wing had representatives in the TACC. These representatives provided the theater-level planners with wing perspectives. Additionally, the wing representatives at the TACC gave their units advanced notice of the tasking in the ATO, so that the unit mission planning process could begin before the publication and dissemination of the ATO. Personal contact with known individuals was an important part of the campaign and mission planning process.

Because the ATO was very lengthy, extraction of the information in the ATO was a difficult process. Typical information for a specific mission would be contained in four different sections of the ATO, and detailed knowledge of where to look for and how to interpret the mission information was needed to develop a mission plan and in-flight data packages. Wings and supporting units used innovative techniques for extracting crucial information from the ATO. These techniques centered on search "programs" designed for personal computers. One problem was that each wing and supporting unit developed its own computer-assisted programs for deciphering the ATO. These programs varied in efficiency and effectiveness depending on the computer expertise in each wing. Nevertheless, the job was done.

The objective of wing mission planning cells was to provide mission leaders and flight members with a set of flight plans, maps, and mission data cards that would enable them to conduct individual flight and tactical planning on a timely basis. The use of designated planning cells to translate campaign-level ATOs into mission-level information is an inherent part of the planning process. Once this was completed, missions could be launched to accomplish their task.

This subsection has described the planning process from the joint theater-level through mission planning at the operational units. At each level, comprehensive and time-consuming procedures and planning aids had to be employed to launch integrated attacks. The time required to complete planning for a daily mission meant that tactical situations on the battle area would change before the attacking aircraft flights arrived in the target area. The change in tactical situation in the battle area occurred even with the relatively static state of the Iraqi army. Targets would move or disperse and new lucrative targets would be

discovered in the course of the day's battle. In addition, unusually bad weather sometimes obscured planned targets and forced flights to be shifted to other areas. Therefore, a battle management system was, and always will be, needed to shift missions on a dynamic real-time basis to targets of immediate importance. The planning system establishes the weight of effort and coordinates the assets and functions of the air-land battle; the battle management system focuses the attack missions in response to the changing tactical situation. The next subsection describes elements and functions of the battle control system in Operation Desert Storm for the part of the campaign directed against the Iraqi ground forces in the KTO.

The Battle Control System in the KTO

The battle control system in the KTO provided mission and engagement control for all coalition air forces. The structure for the battle control system used in the campaign against the Iraqi forces in the KTO was designed and integrated before the beginning of the war in Desert Shield. It was modified to adjust to tactical needs during Desert Storm. Unlike the Central European and Korean theaters, there was no existing command and control system before the deployment of forces to the Gulf region in August 1990. For Desert Storm, the elements of the command and control system were deployed and integrated from the ground up. Further, all of the coalition forces used the command and control system developed by the U.S. forces. In particular, this meant that the battle control system for the KTO had to be a multinational, interoperable system in addition to being responsive to the needs of the battlefield.

The battle control system for the coalition air forces in Desert Storm can be divided into several different functional areas: surveillance and reconnaissance, mission control, engagement control, and assessment. The assets and personnel involved in these functions overlapped by having capabilities and responsibilities in more than one area. The roles that assets performed changed with time as the tactical situation evolved and the capabilities and limitations of different systems under combat conditions became clear. The role of different systems and agencies in performing these functions is shown in Table 4.1.

The surveillance and reconnaissance assets had the tasks of locating and identifying Iraqi ground force units so that they could be targeted and attacked. This function involved a wide array of assets, including satellites, airborne platforms, and ground assets and units. Airborne platforms played the largest role in this functional area. Eighteen RF-4Cs and F-14s with TARPS were the

Table 4.1

Roles for Assets Used to Control the KTO Air Campaign

Asset	Role			
	Surveillance and Recce	Battle Control	Engagement Control	BDA
U-2/TR-1	XX			
ASARS and imagery	X			XX
AWACS (ACE)	X	XX	X	
ABCCC		XX		
Joint STARS	X		XX	X
Killer Scout	X		XX	X
A-FAC OA-10/OV-10	X		XX	XX
GFAC			X	
TACC		X	XX	
ASOC/Marine DASC		XX	XX	
Space	X			X
RF-4C	XX			X
Attack aircraft	X			XX

NOTE: XX denotes a primary role; X denotes a secondary role.

primary manned reconnaissance platforms for Desert Storm. ASARS, a synthetic aperture radar on the U-2, performed real-time reconnaissance for interdiction aircraft. Joint STARS performed the same function and used its moving target indicator (MTI) and synthetic aperture radar (SAR) to locate Iraqi ground forces on the move and in static locations. In addition to these dedicated surveillance platforms, airborne forward air controllers in OA-10s and OV-10s, Killer Scouts in F-16s, and to a lesser degree, all attack sorties performed the surveillance/reconnaissance function in the KTO. Space assets periodically modified the picture of Iraqi force deployment and disposition.

Mission control is necessary to adjust the plan to the changing tactical situation. Through this process, attack flights are assigned to battle controllers, or target areas, on a real-time basis. Mission control agencies and assets are the bridge between the plan (ATO) and mission execution. Different agencies and platforms performed the role depending on where missions were tasked and their individual capabilities.

The TACC had the overall responsibility for real-time mission control. However, the TACC relied on information generated by others to develop a picture of the tactical battlefield situation and had to rely on guidance from other elements of the battlefield command and control system. The TACC performed an essential

role in large-scale force control on the day of mission execution, and it was the approval agency for actions taken by others.

AWACS was responsible for providing mission control for interdiction sorties in the flight-lead control zone (north of 30°30'N). Throughout most of the war, these missions were conducted north of 30°30'N, the part of the KTO north of Kuwait. Flights tasked for missions in the area under control of AWACS would check in and either be sent to their planned target or be directed to a more lucrative target location by the Alternate Command Element (ACE). Additionally the ACE, a colonel with a two-man staff on the AWACS, had responsibility for deconflicting and adjusting air refueling assignments. AWACS also deconflicted air traffic when tasking permitted; however, this was not a high-priority task.

The ABCCC was responsible for the battle control of close air support and air interdiction sorties. The areas of responsibility for the ABCCC shifted over the course of the war as limitations on this platform's capability for battle control were identified. For example, on February 4, the ABCCCs had the responsibility for real-time control of missions for the area south of 30°N. On February 15, the ABCCC's area of responsibility was compressed to the area south of 29°30'N. During this time period, the eastern and western ABCCCs split responsibility on either side of a north-south line positioned at 46°30'E. After February 19, the area ABCCC was assigned responsibility for controlling attacks in specific kill boxes.

The ABCCC was limited in its capability to provide control because it did not have a real-time air and ground picture. The ABCCC's information was restricted to that which could be passed through voice communications from the ASOCs, Marine DASC, and in-flight reports from attack flights. Communications were constrained by the placement and number of antennas on the aircraft. The antennas were on the lower side of the aircraft. The attack flights generally flew above the ABCCC en route to their targets to conserve gas and rendezvous with tankers. Further, the crews manning the ABCCCs had the same difficulty as everyone else in manipulating the lengthy ATO. The ABCCC did not have computers that could correlate the ATO with the real-time picture produced by in-flight reports and provided by surveillance/recce assets. These deficiencies limited the effectiveness and timeliness of control provided by the ABCCC.

The ASOCs are Air Force planning staffs collocated at corps Tactical Operation Centers (TOCs). The personnel at the ASOCs were directly involved in the daily planning process with the corps and shared the corps commander's picture of the battlefield along with his plans. Each corps had a daily allocation of sorties. The ASOCs worked with the TACC to adjust missions among corps as the tactical

situation varied. To perform their functions in a timely manner, an informal procedure was established between the ASOCs. The ASOCs benefitted from consistent communications and well-established working relationships with one another and the corps staffs. When possible, mission control adjustments were worked out between the ASOCs and submitted to the TACC. If time did not permit, mission control decisions by the ASOCs were implemented through direct communications with incoming attack flights. The TACC was informed for approval after decisions were executed when time did not permit. The ASOCs provided needed flexibility to the force allocation process.

The ASOCs performed additional roles in the conduct of the campaign, because they had a real-time picture of the battle area in their respective zones and had access to corps plans. Fighter wings tasked in their respective corps area established a gradually increasing practice of contacting the ASOC for an intelligence update during the planning process. Wings placed great value on information obtained from the ASOC. ASOCs were regarded as the best source for an ingressing attack flight to obtain current information on the FSCL.

The Marine DASC performed the same force allocation role as the ASOC for the MARCENT sector. The Marine DASC moved missions from CAS to AI as required. Pilots operating with the Marine DASC reported that it performed its job very effectively and that its communications were good.

Engagement Control in the KTO

The mission control assets in Desert Storm were used to adjust the ATO by shifting missions into critical areas as the tactical situation developed. In the target area, mission accomplishment is enhanced by battle control assets and procedures to aid target acquisition and identification. Once the mission control process directed attack aircraft flights to the intended area of operation, a variety of means of control were employed for target acquisition ranging from flight-lead control to specific directions from Joint STARS.

Procedures and flight-lead mission control were the most direct means of engagement. For interdiction missions north of 30°30'N, this was the principal means of battle control. AWACS would update the tactical situation or retarget attack flights by providing new geographic coordinates to the flight lead. The kill box grid was also used as a means of control. For example, an attack flight could be sent to box AF7SE. This meant that it would proceed to the southeast corner of the AF7 box and search for a certain type of activity. By referring flights to a location on a common grid, flight members could better acquire

targets by studying grid maps en route. This entailed juggling maps in the cockpit but allowed en route target study to be more focused.

A more precise form of battle control was provided by the Killer Scouts. The Killer Scout concept of operations was to operate a two-ship flight continuously in each assigned kill box. To do this, six aircraft, three two-ship flights, cycled back and forth to a tanker over a four-hour time block. Each flight would remain in the box for a half-hour. The use of Killer Scouts began on 1 February, and their operations increased in size and scope throughout the duration of the campaign in the KTO. The Pointers, as they were also called, came from a single squadron of the 388th Tactical Fighter Wing (TFW), which operated during daylight hours. Marine two-seat F/A-18Ds also conducted Killer Scout mission control.

Typically, the Pointers would enter the area 15 minutes before the first attack flights. They would survey the planned targets for each mission and also look for lucrative alternative targets. After February 11, they were specifically tasked to assign flights to targets. Additionally, the ABCCC was not allowed to divert aircraft into the Killer Scouts area without permission of the Scouts. By 15 February, the Killer Scouts were also tasked with providing battle damage assessment. When the ground war started, the Killer Scouts operated as a buffer between close air support and interdiction. They operated from the FSCL to 30 nmi beyond. Since few air attacks were conducted in the close air support area inside the FSCL after the ground war started, the role of the Killer Scouts was very important.

The Killer Scouts and the airborne forward air controllers (AFACs) provided continuity of operations. After three or four missions in a kill box, the pilots became intimately familiar with the area. They could quickly recognize changes in the disposition of the target set. In addition, wing intelligence for the Killer Scouts kept an extensive database on a computer spreadsheet of targets and attack results in the assigned kill boxes.

Engagement control for attack missions south of 29°30'N was provided by AFACs before the ground war started. AFACs and ground forward air controllers (GFACs) provided control for sorties inside the FSCL. The permission of the ground commander was required to employ weapons inside the FSCL, and the FACs were the agent providing that permission. The FSCL moved even before the beginning of the ground war. Its location was published daily in the ACO. Only part of the missions controlled by OA-10s and OV-10s were CAS missions.

Unlike the Killer Scouts, the OA-10s and OV-10s generally operated alone, and they operated around the clock. OV-10 aircraft were tasked daily for multiple sorties to provide continuous coverage for the MARCENT sector. The OA-10s established the same continuity of operations as the Killer Scouts, except they operated from the beginning of the air campaign. OA-10 pilots marked targets with Mk-82 bombs and rockets and used formatted briefings to direct aircraft to specific targets. To assist in locating and identifying targets, the forward controller in the OA-10 used binoculars, but their utility was somewhat limited because the aircraft does not have an autopilot. OV-10s operated near 10,000 ft; Killer Scouts at 15,000 to 20,000 ft. They believed that their lower operating altitudes and slower speed enabled them to function more effectively than the Killer Scouts. In addition, the OA-10 and OV-10 FACs often worked with A-10s and Marine AV-8Bs, respectively. Familiarity between these respective systems reduced unnecessary communications and increased effectiveness as a team.

GFACs were assigned down to the battalion level. Generally, the GFACs experienced a very uneventful war other than participating in the advance through Kuwait with the coalition ground forces. Very few close air support missions were conducted before the ground war, and because of the rapid-moving nature of the campaign, GFACs controlled very few attacks during the four-day offensive. After the ground war started, over 1000 sorties per day were allocated for CAS, but few were used in that role. Generally, air attacks were kept 8 km, or more, from advancing coalition forces. GFACs typically controlled only one or two attack missions, and those were procedural attacks well ahead of ground forces. GFACs regarded Global Positioning System (GPS) receivers as invaluable in maintaining situation awareness. Because of the scale of air operations and the level on which ground force planning is conducted, most believed that there was little value added by having GFACs below brigade level.

A special engagement control asset used in the KTO campaign was Joint STARS. Joint STARS became operational in the theater the day before the campaign began. It is both a surveillance and a battle management platform. Initially, it was employed in the surveillance role only. For the first 10 days of the war, the concept of operations for Joint STARS was to pass likely targets to the ABCCC, which then relayed the information to attack fighters. On January 27, Joint STARS began providing control directly to the F-15Es. The following day, procedures for Joint STARS targeting were published in the ATO. On the 29th, Joint STARS combined with the advanced synthetic aperture radar system (ASARS) picture on the TR-1s to give fighters a complementary picture. Then, on the succeeding day, F-16s equipped with LANTIRN navigation pods were also provided direct battle control from Joint STARS. Joint STARS targeting was also

used for Scud hunting in addition to controlling missions against the Iraqi ground forces in the KTO.

Most feel that Joint STARS would have been even more effective if it had GPS and a direct data link (rather than voice control) to attack aircraft. It was used with only a limited number of attack aircraft, so the full span of control of the platform was not fully tested. Nevertheless, Joint STARS was very successful in the surveillance, force allocation, and battle management roles.

Battle Damage Assessment

Desert Storm was a war conducted on a schedule. The schedule was predicated on completion of specific well-defined tasks, such as reduction of the Iraqi army to 50 percent of its original combat power. This presented a challenge. The challenge was not in employing forces to meet the operational objectives but in measuring the accomplishment of the objective. At best, measurement of progress toward that goal was an inexact science.

It is difficult to keep score in combat. Mission results were submitted after each sortie by means of MISREPs. The utility of MISREPs in providing assessments of battle damage and mission success varied. They were virtually useless in assisting mission planners. It is very difficult to obtain an overall assessment of mission results through MISREPs alone. Units with a precision weapon delivery capability frequently had pictures of weapons impacts, but even with this evidence near misses would appear to be kills. Assessment of results for aircraft employing "dumb" bombs was even more difficult. Release parameters could be recorded, but results were air-scored based upon flight observations. Nevertheless, most of the fighter wings involved in Desert Storm believed they had fairly good knowledge of results achieved in the missions they flew. However, the overall BDA responsibility was an important task that had to be calculated through a consistent, command-accepted process.

ARCENT and MARCENT were given the responsibility for ground operations and therefore were assigned responsibility for BDA in the KTO. A complicating factor was that the means for BDA mainly belonged to CENTAF. Naturally, fighter wings and ARCENT saw the results from a different perspective, which created a degree of friction. The accounting protocol finally adopted credited one-third of the kills claimed by the A-10s, one-half of the kills claimed by the F-111F and F-15E force using LGB, and all those confirmed by photography or by the Ground Liaison Officer. Although this was less than exact, it was accepted as the accounting standard.

Keeping track of the rate of attrition of the Iraqi army was critical because the initiation of the ground campaign was based upon this measure; therefore, everyone was concerned about progress toward the objective. ARCENT was not the only participant in the process. Others kept score too. For example, using the results of sensors on airborne and space platforms, the DIA produced an estimate which assessed the destruction of the Republican Guard's Tawakalna Division at only two-thirds the value assessed by ARCENT on February 15. Similarly, the CIA briefed the President on February 21 that it could validate only one-eighth of the kills claimed by ARCENT. The problem was not that there was no BDA, but that different agencies had different assets and procedures for BDA. And they produced different results.

Assessment of the results is an important aspect of modern warfare and was one of the more contentious aspects of the war in the Gulf. An assessment process was necessary to adjust the overall campaign planning and day-to-day battle plans (ATO), and for accurate mission and engagement control. Results can be assessed from a variety of different assets: space systems, airborne surveillance and reconnaissance platforms, attack aircraft, and control assets, which together provide a consistent view of the battle area. The challenge is to develop a process and responsibility to integrate the results viewed from multiple sources into a coherent picture. Because an "event scheduled" war was a new phenomenon, the process was invented in Desert Storm as the campaign proceeded.

5. Operational Challenges

The air campaign in the KTO was an unprecedented undertaking both in its scale and in its results. Nevertheless, any operation of this size will encounter problems, and there will be challenges to overcome. Even with meticulous planning, it must be remembered that "Murphy's Law" is always in effect. Therefore, we made a point of asking which problems were encountered and what can be done to fix them in future operations. This section discusses the challenges and problems either that were brought up by the participants or have been perceived as problems.

Communications

Participants in Desert Storm gave a common response when asked which problems were encountered. The common response was "communications." It was clearly frustrating not to be able to talk to an aircraft, or control facility, that possessed the instruction necessary to carry out the mission. Sometimes that was not possible. Fortunately, the instructions for the conduct of the air campaign were flexible, and aircrews could often accomplish their missions without external assistance when communications were degraded.

The most frequently cited communications deficiencies fell into several categories. First, the communication suite on the ABCCC had limitations. Next, control facilities and ground agencies frequently reported difficulties with ultra high frequency (UHF) SATCOM, particularly in the KTO. Finally, it was difficult to organize and use secure and antijam systems in an operation of this size where multiservice and multinational units conducted joint operations.

The ABCCC was designed to control the CAS battle. It was developed to stand back from the battle area and control aircraft flying toward the front at low altitude. It also was designed to provide control over a corps-sized area of responsibility.

In Desert Storm, the attack aircraft remained above 20,000 ft for air refueling to save fuel, to deconflict air traffic, and to stay above the threats. Additionally, aircraft flew long distances to get to the battle area. While en route, they wanted to contact ABCCC early to build situation awareness. As a consequence, flight leads often attempted to contact the ABCCC beyond the effective range of its

radios. If contact was not made on the first several tries, flights would go to another agency for control, or simply proceed with preplanned mission tasking.

Several workarounds were attempted. First, instructions were provided to wait until aircraft were near the ABCCC orbit to attempt communications. In addition, radio relay, EC-135 aircraft, were also used to alleviate the problems. These fixes were only partially successful.

UHF SATCOM was reported to be saturated, particularly near the KTO. In the region near the front, many units had SATCOM equipment. Mutual interference resulted. The simple scale and scope of Desert Storm produced new problems. Because of SATCOM saturation, USAF ground agencies and the operational units expressed a preference for secure high frequency (HF).

Distribution of secure communications codes proved to be a problem. Theoretically, these codes are distributed and changed daily. Management and distribution across a theater the size of the Gulf region to multiple services proved too much of a challenge. It was particularly difficult to get the right materials to ground units dispersed in the field. As a consequence, secure communications codes were frozen before the ground war began until the end of the campaign.

A similar type of problem occurred with the Have Quick antijam radio. Although flights practice with this equipment regularly in training, it is seldom used on operations of this scale. Many aircraft had difficulty getting an accurate time of day (TOD) signal, and without a common TOD signal the frequency-hopping feature, which is the basis of the antijam system, was not synchronized. For an antijam radio system to be effective, all participants must be able to use it, and in Desert Storm some of the aircraft were not equipped with Have Quick, particularly the U.S. Navy and the non-U.S. coalition aircraft. Therefore, many composite flights could not even attempt to use the system. When it became apparent that the Iraqis were not going to attempt to jam tactical frequencies, antijam radio usage decreased.

A related challenge that arose in part because of particular communications limitations in the KTO was air traffic control. The existing facilities did not have the capacity to separate the traffic that transited into, around, and out of the KTO. Many pilots said that the thing they feared the most while operating in the KTO was a mid-air collision with another attack flight. In fact, Royal Air Force pilots turned on their anticollision beacons and aircraft identification lights, believing that the danger of a midair collision was greater than the risk of being engaged by Iraqi defenses.

The Airspace Coordination Order contained an elaborate scheme for procedural airspace control with entry, exit, holding, and operating altitudes. Since no mid-air collisions occurred, these procedures obviously worked. However, judging by the number of comments we heard and the traffic density in high-tempo combat operations, means to overcome saturation of communications and controllers could improve future operations.

Communications is the foundation of a modern fighting force. Considering the scale of operations and the fact that there was no existing military communications infrastructure in the theater before the Iraqi invasion of Kuwait, communications functioned well. There were frustrations, and certainly improvements can be made through planning and attention to the problems encountered in Desert Storm.[1]

Fratricide

The loss and injury of friendly combatants is a cause for concern, and consequently fratricide has received much public attention. The circumstances have been investigated in great depth by the armed services, and we will not repeat their efforts but will provide some general observations about these unfortunate incidents. The bigger story on fratricide lies in the incidents that did not happen. Despite a congested air environment, there were no air-to-air or friendly surface-to-air fractricide cases.

There were nine reported cases of fratricide involving fixed-wing aircraft under CENTAF's responsibility. The fratricide cases for fixed-wing aircraft were of two types: accidental attacks on coalition ground force armored vehicles and the unintentional engagement of friendly radars by the antiradiation missile, HARM. There were no cases of inadvertent attack of fixed coalition ground force positions by fixed-wing aircraft. It is also worth noting that there were about twice as many ground-to-ground fratricide incidents as air-to-ground cases. The increasing range and lethality of antitank missiles and weapons makes the ground-to-ground cases similar in many instances to the air-to-ground situations. In modern warfare, engagement will frequently occur beyond the range where the target can be visually identified.

Heavy emphasis was placed on avoiding fratricide by coalition air forces. Permission was required from the responsible ground commander to attack any

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[1]For a detailed analysis of communications in Operation Desert Storm, see Leland Joe and Daniel Gonzales, *Command, Control, Communications, and Intelligence Support of Air Operations in Desert Storm* (U), RAND, N-3610/4-AF, 1994, Secret/NOFORN/WNINTEL.

target inside the FSCL. Generally, air strikes were conducted farther than 8 km from coalition ground forces. New procedures for the conduct of support of ground forces were issued on February 15, just before the ground war, to minimize the probability of fratricide. When these detailed procedures for the conduct of the ground war were transmitted, CINCCENTAF personally cautioned aircrews not to attack the "next General Patton." The general rule was "If in doubt, don't attack." It must also be added that there are several anecdotal reports of pilots ceasing an intended attack when things "didn't look right."

There is a common denominator in the fractricide cases involving coalition ground vehicles. All but one of the incidents occurred at night. In two of the four cases where moving coalition armored vehicles were attacked by fixed-wing CENTAF aircraft, the attacking aircraft were uncertain of their position. It was more a question of not knowing exactly where they were than not knowing where friendly forces were supposed to be. At the ranges from which most modern weapons are fired, the principal identification means is by location (situation awareness) rather than visual identification. For Maverick, Hellfire, TOW, LGBs, and most future weapons, the target is at the edge of the range where it can be identified visually. The incorporation of a GPS receiver on all attack aircraft may reduce the potential for fratricide.

There is a popular hypothesis that the likelihood of fratricide is increased for fast-moving aircraft, because they cannot recognize targets flying at high speed. The air-to-surface fratricide cases involved A-10s, an A-6E, and an AH-64. The evidence suggests that this hypothesis is not true. The slower aircraft such as the A-10 generally worked closer to friendly troops, increasing the possibility of fratricide.

The most frequent type of air-to-ground fratricide was "electronic fratricide." If a HARM is launched against an emitter that shuts down, in some modes it will search for any other emitter in the same frequency range. All of the electronic fratricide cases occurred in the KTO or at sea. HARMs launched from Air Force and Navy aircraft were inadvertently guided toward two friendly ground unit fire direction-finding radars and two shipboard radars. These are cases of electronic misidentification by the missile after launch. Though not lethal, another form of electronic fratricide also occurred when friendly jammers interfered with friendly radars and communications.

Overall there were very few fratricide incidents. These cases stand out because the coalition forces were so successful in overwhelming the Iraqis, and there were very few combat losses. The cases are unfortunate because of the loss of life and the injuries that resulted. However, it is important to recognize the success

of the detailed planning and procedures, and the professionalism of the people involved in keeping the number of incidents as low as it was.

Attrition

The effectiveness of attack aircraft in Desert Storm is a product of the munitions employed and the avionics used to locate targets. Survivability is far more a function of the threats, the type of aircraft, and the tactics employed. In Desert Storm, there were remarkably few aircraft losses. The overall rates of attrition were lower than those projected by over a factor of ten. The threat was significant, but it was suppressed, avoided through tactics and training, and defeated in detail.

The Iraqis concentrated their radar SAMs around Baghdad, protecting the capital at the expense of the troops in the field. Some radar SAMs were located in the KTO, but far fewer radar SAMs were deployed to protect 43 divisions and their equipment than the Soviets would have doctrinally deployed to protect a single division. The AAA was heavy throughout the KTO and threatened any aircraft that operated below 10,000 ft. IR SAMs were used sparingly but were effective at times. The general approach to defeat the surface-to-air threat was by suppressing radar SAMs and remaining above the effective range of IR SAMs and AAA. It is reported that most EW radar activity ceased in the KTO by the tenth day of the air campaign.

Pilots flying in the KTO report that AAA was dense and affected their ability to perform their mission, principally by forcing them to remain high. A belt of SAMs existed in the Republican Guard positions. This is consistent with the Iraqi philosophy of protecting the elite. In addition, there was a belt extending west for 20 miles from the southern side of Kuwait City called "Flak Alley."

Aircraft losses in the KTO are grouped over three short time periods: January 30 to February 2, February 6, and February 15. This suggests that the Iraqis (for good reasons) were very selective about when and where they attempted to engage aircraft with surface-to-air defenses. Pilots reported that heavy defensive reactions occurred when they lingered in the target area too long or allowed themselves to fly low and slow. This observation falls into the category of "old lessons relearned from past wars."

All these rates are very low considering the threats and other experience in modern air combat. A simple comparison to the attrition suffered by the Israeli Air Force in the 1973 Yom Kippur War (over 15 percent along the Suez Canal for the first three days, and 3 percent for air-to-surface missions over the course of

the war) against the same type of threats illustrates the improvements made in defense suppression over the past two decades. The relatively high loss rates for the AC-130 and A-6E are driven by the fact that these aircraft flew comparatively few sorties and still experienced losses. The small number of sorties flown drove the rate up.

The higher loss/damage rate for the A-10s was driven by the losses and damage experienced in a short period. For a few days at the end of January, the A-10 force was tasked to attack Republican Guard positions. The A-10s had previously been effective attacking forces in the tactical echelon, and the surface-to-air threat was diminishing. Therefore, A-10s were sent deeper to inflict more damage on the Republican Guards. Over two days, 10 A-10s were lost or damaged, and then they were brought back to the mission of attacking the tactical echelon forces. It is worth observing that, although a number of A-10s were damaged, the losses were reduced by the protection built into the aircraft. Slower aircraft appear to have experienced higher loss/damage rates. Lower operating speeds produced longer exposure times, and generally these aircraft operated at lower altitudes within the effective range of more threat systems.

The low attrition in Desert Storm provides only a limited sample, and any results or conclusions about survivability must be viewed carefully. Nevertheless, the defense suppression and the self-protection systems on the U.S. and other coalition aircraft created a situation in which all types could operate with relative impunity.

Difficulties are an inherent part of any military operation, and Desert Storm was no exception. The challenges discussed in this section are noteworthy in the comparatively small effect that they had on the overall scale of operations. It is also significant that the forces were sufficiently flexible to adjust to changing conditions and challenges. This is a direct result of the realistic training that has occurred over the past two decades. In the next section, we will examine the performance of individual systems.

6. System Effectiveness

Wars do not lend themselves to clean statistical results. One assessment of coalition effectiveness can be observed in the fact that 43 enemy divisions were reduced to about one-third of their original combat strength before the start of the ground war, and in the relative ease with which the four-day ground campaign was conducted. The results of the air campaign based on the assessment system developed by ARCENT for CINCCENTCOM on the day before the ground war began are shown in Table 6.1.

The attack force used in the air campaign in the KTO came from all four services and the coalition allies. The level of effort increased throughout the course of the campaign, and the tactics and tasking changed in response to the developing tactical situation.

A-10s and F-16s provided the largest number of sorties against the Iraqi army. About 132 A-10s and 12 OA-10s operated principally against the tactical and operational echelons of the Iraqi army. The F-16 force averaged over 200 sorties daily in the KTO, primarily against Iraqi forces in the operational and tactical echelons. F-111Fs and F-15Es contributed principally through tank plinking after the first week in February. B-52s attacked the Republican Guard positions daily throughout the war.

The Marines operated with around 84 AV-8Bs, 72 F/A-18s, and 20 A-6s from bases in Saudi Arabia and Bahrain. These aircraft conducted their attacks mainly in the MARCENT sector. The Navy, operating from carriers in the Arabian Gulf and Red Sea, began by concentrating on the attack of naval targets and bridges, and then gradually shifted their emphasis to the Iraqi ground forces. Toward the end of February, the Navy was providing up to 150 sorties per day in the KTO from F/A-18s, A-6s, and A-7s.

Coalition air forces, which also contributed an ever-increasing number of sorties against the Iraqi forces in the KTO, comprised in the beginning Kuwaiti A-4s and Mirage F-1s operating together in formations for positive identification, French Jaguars, and Saudi Tornados and F-5s. As time passed, these coalition aircraft were complemented by British Tornados and Buccaneers, CF-18s, French Mirage 2000s, and Qatari Alpha Jets and Mirage F-1s.

Table 6.1

KTO Battle Damage Assessment as of 23 February

	Strength			Total Losses			Capital
	Tanks	APC	Arty	Tanks	APC	Arty	%
ARCENT/NAC/AO							
Theater echelon							
Medina	312	177	90	178	55	36	54
Hammurabi	312	177	90	98	14	23	77
Tawakalna	222	249	90	112	73	70	55
Nebuchadnezzar	35	0	72	13	2	0	88
Alfaw	35	0	72	0	1	0	100
Adnan	72	0	72	24	0	0	83
Total	988	603	486	425	145	129	66
Operational echelon							
12th Armor	249	177	90	117	36	66	58
17th Armor	249	177	72	82	44	21	70
52nd	249	177	72	136	61	5	59
10th Armor	249	177	72	77	62	59	60
6th Armor	249	177	72	149	116	59	35
53rd Armor BDE	107	35	18	59	38	19	30
Total	1352	920	396	620	357	229	55
Tactical echelon							
48th Inf	35	0	46	24	17	17	49
25th Inf	35	0	36	11	2	31	41
28th Inf	35	0	72	31	9	71	5
27th Inf	35	0	72	45	18	57	14
26th Inf	35	0	72	14	3	18	70
31st Inf	35	0	72	13	5	50	41
47th Inf (Light)	140	70	204	53	17	129	52
45th Inf (Light)	37	11	36	17	4	11	62
49th Inf	36	0	72	7	0	0	94
20th Inf	35	0	72	26	1	45	34
16th Inf (Light)	70	70	72	73	45	45	25
36th Inf	35	35	72	46	17	40	35
30th Inf	35	0	723	29	20	90	6
21st Inf	35	0	90	57	3	53	30
Total	633	186	1060	446	161	657	33
ARCENT/NAC total	2973	1709	1942	1491	663	1015	52
MARCENT/AO							
Tactical echelon							
29th Inf	142	35	144	17	9	59	74
8th Inf	142	35	144	30	24	64	63
5th Mech	177	249	72	32	145	42	56
80th Armor BDE	107	35	18	0	0	6	96
C Inf (Revised)	0	0	0	0	0	0	0
14th Inf	142	35	72	21	35	62	53
18th Inf	142	35	144	24	4	36	80
7th Inf	107	35	144	92	24	127	15

Table 6.1—continued

	Strength			Total Losses			Capital
	Tanks	APC	Arty	Tanks	APC	Arty	%
MARCENT/AO							
Operational echelon							
1st Mech	177	249	72	15	1	25	92
3rd Armor	249	177	72	37	23	6	87
19th Inf	142	35	72	1	0	8	96
11th Inf	70	107	72	0	0	0	97
15th Inf	35	35	72	4	0	0	97
42nd Inf	35	35	72	2	3	7	92
Theater echelon							
51st Mech	177	249	72	5	17	12	93
2nd Inf	142	35	72	1	0	4	98
E Inf	35	35	72	0	0	0	100
D Inf	35	35	72	0	0	1	99
MARCENT total	1949	1416	1314	281	285	459	78
KTO total	4922	3125	3256	1772	948	1474	63

SOURCES: MARCENT and ARCENT DDA tables.

Mission results cannot be easily synthesized into sortie and weapon effectiveness from the documentation available. The mission results were reported through MISREPs. However, these reports are not complete and vary in quality. The MISREPs range from detailed results verified by aircraft videotape recorders (VTRs) showing equipment exploding to comments that weapons impacted the target area. VTRs on the attack aircraft and weapon sensors were used extensively to assess and report mission results. These recorders were useful for evaluating the mission results for precision weapons. But the VTRs did not have the same utility in assessing the results achieved with free-fall weapons. For ballistic weapons, VTRs are very helpful for flight crews in evaluating release parameters and target acquisition; however, these recorders did not generally show weapon impact and the ensuing mission results.

The official ARCENT BDA process that was adopted and improved through the war tracked total losses by Iraqi division in the KTO for tanks, APCs, and artillery. This count included only mission results from A-10s, F-111Fs, and F-15Es; it credited one-half the kills verified using videorecorders by the wing Ground Liaison Officer (GLO) for F-111Fs and one-third of the GLO-verified kills from A-10 squadrons. Further masking the problem of determining sortie/system effectiveness is the fact that the targets that were systematically tracked (tanks, APCs, and artillery) were only part of the target set that was attacked. For example, the A-10s concentrated on these targets because of the missions that they were tasked for. However, tanks, APCs, and artillery accounted for only 57 percent of the targets confirmed destroyed by A-10 units.

The rest were a mixture of trucks, buildings, air defenses, surface-to-surface missiles, bunkers, and airfield targets. There was no formal assessment system for targets in the KTO other than armor, artillery, and APCs.

The problem of assessing results was further compounded because attack aircraft conducted most of their attacks from medium altitude (above 10,000 ft). At these ranges, it was difficult to determine exactly what the target was and what happened to it. Tanks could look like APCs, and trucks in bunkers could be mistaken for combat vehicles. Further, it was not always possible to determine if a vehicle had been previously damaged or destroyed.

The following subsections provide a qualitative assessment of the principal USAF aircraft used in the KTO against the Iraqi army. It is a synthesis of a review of MISREPs, a viewing of selected videotapes of combat missions, and interviews with aircrews who participated in the campaign. We limit the discussion in this section mainly to USAF aircraft and systems, because we had direct access to the aircrews in the course of our assessment. The effectiveness of a particular aircraft in Desert Storm is primarily a product of the weapons it employed and the sensors used to acquire targets. Given the same weapons and sensors, we expect that most aircraft would have achieved similar results for the target sets in the KTO.

Aircraft Effectiveness

A-10

Desert Storm was well suited for the A-10s' characteristics. The radar SAM threat was relatively thin and suppressed early. Antiaircraft artillery was dense, but the threat from guns could be minimized by remaining above 10,000 ft. The A-10s generally used 10,000 ft release altitudes until the first week in February. Then, weapon release altitudes were lowered to 8000 ft. For target acquisition/identification, A-10s would descend briefly to 6000–7000 ft. After these short excursions to below 10,000 ft for weapon employment and target acquisition, the A-10 flights would return to medium altitude to minimize the threat from AAA fire. Staying at that altitude also reduced exposure to the enemy's IR SAMs.

Persistence was generally needed to locate and destroy the Iraqi ground force targets. The A-10s' endurance enabled them to remain in the target area and search for targets. The persistence of the A-10s produced an important secondary result in the outcome of the war. A captured Iraqi officer reported that, although the actual bomb run (of the A-10s) was terrifying, the aircraft's

loitering around the target area before target acquisition caused as much, if not more, anxiety, since the Iraqi soldiers were unsure of the chosen target.[1]

Over the course of the campaign, the A-10 force claimed to have destroyed 987 tanks, 926 artillery pieces, 501 AFCs, 1106 trucks, and 698 others targets. Generally, the A-10s attacked the areas adjacent to the Saudi/Kuwaiti border, where the traditional CAS mission was performed. These aircraft were tasked as four-ship flights during the day and two-ship flights at night. A-10s were also used extensively at night. Night missions were conducted without the benefit of a FLIR or night vision goggles. The A-10s dropped flares to illuminate the battle area, and they also used the imaging infrared (IIR) seeker in the AGM-65D missile to search for targets. They flew in Joint Air Attack Tactics (JAAT) missions with Army AH-64 helicopters, with AC-130 gunships, as SAM hunters (defense suppression) teamed with F-4Gs, and as Scud hunters during the daytime.

The A-10s from the 23rd and 354th Provisional TFWs employed a wide range of ordnance. Over the course of the campaign, they expended about one million rounds from their 30 mm cannon, 5255 TV and IIR AGM-65 missiles (62 percent of the total were IIR missiles), 19,884 Mk-82 and Mk-84 bombs, 7032 older cluster bomb units (CBU-52/58/71 and Mk-20 Rockeye), 746 CBU-87, and 5488 flares for night operations. A typical ordnance load for A-10s was 2 AGM-65 Mavericks (1 EO and 1 IIR missile), or 4 bombs, and a full load of 30 mm cannon ammunition. Late in the war, the Maverick load was increased to 4. The overall weapon system reliability was almost 99 percent from the A-10s.

Precision weapons were the preferred choice when they could be employed. Mavericks accounted for most of the confirmed kills credited to the A-10s. This weapon was highly reliable, exceeding 97 percent for over 5000 weapons. Though we have not seen a comprehensive accounting of the number of hits with Mavericks, over 80 percent of the AGM-65s fired were reported to have hit their designated targets. A sampling of Maverick film assessments from an A-10 squadron showed that 94 percent of 500 missiles were launched with a confirmed lock-on. Reports from the ground survey teams in Kuwait indicated that Maverick hits destroyed the Iraqi armored vehicles. The overall worldwide Weapons System Evaluation Program (WSEP) results over five years are 85 percent for the Maverick and 87 percent for the IR Maverick. It is interesting to note that these figures closely correlate with the results achieved in live fire training in the WSEP.

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[1]The A-10 was called "the Black Jet" by Iraqi soldiers.

Maverick employment was reported to be difficult against vehicles in revetments. Patience and operator technique were needed to get a stable seeker lock-on for revetted vehicles. The lock-on tended to shift from the tank to the revetment. Additionally, early in the war some Mavericks were occasionally used against empty revetments by mistake.

The AGM-65D infrared seeker also served an important secondary purpose. The A-10s tasked for night attack missions used the IR Maverick seeker in addition to flares to search for targets. This technique proved to be helpful even though the pilots were restricted to the "soda-straw" 3 degree field of view. Mavericks proved to be very effective weapons for A-10s in this war in more ways than were originally envisioned.

GP bombs (Mk-82 and Mk-84) and cluster bomb units were also used extensively by the A-10s and other aircraft. From a limited sample of the reported effectiveness using free-fall bombs, around 70 percent were claimed to be "hits." It is not clear what the hit criteria were, however. Additionally, because the aircraft videorecorders captured only release conditions, it is unclear what happened after bomb impact.

GP bombs and CBUs were released from steep (45–55 deg) dive angles at 8,000–10,000 ft. Deliveries were complicated by high winds at altitude. CBUs were used against a wide variety of targets. The pilots specifically reported that CBUs were "effective" against artillery positions, although there are no quantifiable effectiveness criteria. The older family of CBU-52/58/71 weapons in SUU-30 dispensers suffered from reliability problems. Units reported 75 percent reliability (as opposed to reliabilities above 95 percent for most of the other weapons used in the war). The principal problem was cannister functioning. As the war progressed, munitions crews learned how to prepare these weapons to improve the reliability.

The Mk-20 Rockeye was not considered as effective by A-10 pilots. This antiarmor weapon had a small dispersion pattern which did not match the dispersed target sets in Kuwait. The A-10 pilots' experience with Rockeye is different from that reported by Marine units, which liked the weapon. However, it should be remembered that the Marines did not have many precision weapons, and none of the newer CBU family.

Mixed loads of bombs and Mavericks provided A-10s with mission flexibility. Sometimes Maverick employment was not possible. Bombs and the cannon could be used for defense suppression while one aircraft in the flight employed Maverick.

The A-10s used almost a million rounds of 30 mm ammunition. Cannon employment was not easy because the aircraft remained at relatively high altitudes. This resulted in fewer reported hits than with other ballistic weapons (63 percent reported for the cannon compared with 72 percent for bombs). In addition, the dispersion at the relatively long slant ranges reduced the number of hits on targets. The 30 mm cannon was reported to be effective against soft-skinned vehicles such as supply trucks. A-10 crews also used the cannon to survey revetments to see if they were occupied. If it was not possible to tell immediately if a revetment was occupied, A-10 flights would make a cannon pass on the revetment. When the revetment was unoccupied, there would be no visible result. Flashes would be seen if an armored vehicle was in the revetment, and an explosion would result if a truck was parked in the revetment. Although the cannon did not completely fulfill its traditional "tank busting" role, it proved useful in the war.

AV-8B

The 84 AV-8Bs were operated by the Marines on land and off two amphibious carriers (USS *Tarawa* and the USS *Nassau*) in the Arabian Gulf. The Vertical/Short Takeoff and Landing (V/STOL) aircraft is relatively short range and was designed to provide close air support. These aircraft operated principally in the MARCENT sector of the KTO. They performed according to their planned concept by operating from forward bases and amphibious carriers near the forward line of troops. The AV-8Bs used the "push CAS" concept of operations in which they would fly into a designated CAS area first. If no CAS targets were available, the AV-8Bs would proceed deeper and attack interdiction targets. The AV-8Bs operated in conjunction with Marine FACs in OV-10s. Thus, their concept of operations was similar to that of the A-10/OA-10 team.

The primary ordnance employed by the AV-8Bs was Mk-20 Rockeye cluster bomb units, Mk-82 and Mk-83 general purpose (GP) bombs, and the 20 mm cannon. The AV-8B uses an Angle Rate Bombing System (ARBS), which computes release conditions. However, this system does not use radar slant range as an input like the F/A-18s and F-16s, and therefore was not as accurate for weapons delivery. Like the other aircraft without a videotape recording capability to observe weapons impact, it is difficult to obtain an exact accounting of mission results for these aircraft. The sortie rate for the AV-8B aircraft started low. The AV-8Bs averaged 0.9 sorties/day over the course of the war. Using staging bases adjacent to the battle area, the AV-8Bs reached a peak of 218 sorties on the second day of the ground war.

F-16

F-16s flew 24 percent of the nearly 36,000 sorties planned against the Iraqi ground forces in the KTO. Most of their sorties were flown against Iraqi forces in the theater and operational echelons, in the kill boxes centered in the northern half of Kuwait, and in southern Iraq. F-16s conducted a variety of missions: attack missions in the kill boxes, Killer Scouts, night attacks with LANTIRN-equipped aircraft, road and bridge reconnaissance, and fixed-target attacks.

The F-16s mainly used free-fall GP and cluster bombs. The computer-aided delivery systems in the F-16 were believed to be sufficiently accurate to provide satisfactory results with unguided weapons. For this reason, the F-16 force was tasked primarily with "dumb" bomb missions.

The Continuously Computed Impact Point (CCIP) computer/inertial platform bombing system in the F-16 was the primary mode used to deliver ballistic weapons. The accuracy of this system is assessed at 5 to 7 mils. For most of the war, F-16s delivered bombs at slant ranges of 18,000 to 20,000 ft. With everything perfect, this would result in a circular error probable (CEP) of 90–140 ft. At these ranges, the 2 mil CCIP "pipper" covers an area of 40 ft, greater than the size of a tank or a truck. Although this accuracy is satisfactory for buildings and large targets, it is not an effective way to engage hard point targets such as tanks, unless the weapon has a large lethal radius.

The discussion above applies when everything is perfect, and in combat nothing is perfect. A shallow bomb pass with CCIP increases the wind effects, the delivery slant range, and in turn the CEP. Delivery passes in which the "pipper" is not brought through the target at a constant rate can produce additional errors. It is also possible to let aircraft speed increase near the "Mach" on a steep downhill pass with a load of bombs, and that introduces ballistic errors (the release limit for most bombs is 550 KTAS or 0.9 Mach).

Bombing from the F-16 and other aircraft with computer-aided delivery systems in Desert Storm from medium altitudes provided lessons in bomb ballistics.

The results achieved by the F-16 force in the KTO cannot be accurately determined. VTRs capture release conditions only for bombs. Occasionally, bomb impacts from other flight members that preceded a fighter "down the chute" could be seen, but this type of recording was only coincidental. Some results are contained in MISREPs and are based on pilot or FAC reports of bomb impacts or secondary explosions. However, MISREPs do not produce a consistent basis for a quantitative assessment of mission effectiveness. As a

result, the F-16s were not credited in the ARCENT BDA system even though they flew more sorties that any other aircraft in the KTO.

Anecdotal reports based upon pilot interviews give further insights about the effectiveness of free-fall weapons. Mk-84 bombs, with the FMU-113 air burst fuze, were reported to be very effective against armored vehicles. Both F-16 and A-10 pilots reported that this weapon/fuze combination appeared to "melt" tanks. Because of the large lethal radius of this weapon/fuze combination, a direct hit was not required.

F-16 pilots also consistently praised the results achieved with the CBU-87, Combined Effects Munition. This weapon does not require precision accuracy, because its lethal radius is compatible with the bomb delivery accuracy of the F-16 system. It was employed by F-16s in the first weeks of the war, and then it was withheld until the ground war approached, since this new munition was available in only limited numbers. The weaponeering manuals show that the CBU-87 is comparable to the Mk-20 Rockeye. It was much more reliable, and F-16, A-10, and F-15E pilots assessed it as "awesome." Even accounting for any possible exaggeration, the CBU-87 performed quite well.

Some weapons did not work well from the viewpoint of the F-16 pilots. The F-16 pilot force, like the A-10 pilots, regarded the older CBUs as unreliable. Older fuzes also caused problems. Bombs with FMU-139 fuzes sometimes detonated prematurely at the end of safe separation time. This fuze problem caused the loss of one F-16. Subsequently, a very long 10-sec fuze arm setting was used to ensure safety. As in other wars, fuzes became important when the shooting started, and the operators quickly learned which fuze/bomb combinations worked and which did not. Finally, the GPU-5, 30 mm gun pod, was tried for one day. The results achieved with this "close support" weapon were not deemed sufficiently productive to sacrifice carriage of the external electronic countermeasure (ECM) pod on the centerline station.

One squadron of F-16s operated at night using recently acquired LANTIRN navigation pods. This squadron was the only F-16 squadron to employ Maverick. The combination of LANTIRN, onboard radar, and Maverick worked very well. Although the use of Maverick on the F-16 was not as extensive as with the A-10, it was also successful. A 92 percent "hit" rate was reported with 115 hits out of 124 missiles fired. These Mavericks were the only precision munitions employed by the F-16 force. In the future, with the incorporation of LANTIRN navigation and targeting pods on the F-16 fleet, these aircraft will have PGM capability.

F-16 pilots used a number of different modes of the radar in conjunction with the LANTIRN to locate and attack targets at night. Typically, in a two-ship night mission, one aircraft would search the area of interest in the Doppler beam sharpening (DBS) mode of operation to find fixed targets, and the wingman, the other aircraft in the flight, would search in the ground moving target track (GMTT) mode to find moving vehicles. When a possible target was detected, the immediate area would be visually searched with the LANTIRN sensor or the IR Maverick sensor. This combination of techniques was developed and refined as the war progressed.

Two squadrons of F-16s were equipped with the GPS receiver. They were the only USAF fighter/attack aircraft in Desert Storm to have this new system. It permitted these aircraft to know their precise location with respect to a common reference. This system proved very valuable. For example, a flight lead could reference all flight members to the "bunker 10 meters left of the diamond" and everyone would know exactly where to look. Although GPS was a very new system to the F-16, pilots were unanimous in their praise of it.

The results achieved by the F-16s in Desert Storm were not as impressive as those achieved by aircraft that primarily used precision weapons. The F-16 was versatile and performed to system specifications, but it did not live up to the expectations built upon results achieved from low-altitude deliveries. However, the F-16 force provided the numbers to keep constant pressure on the Iraqi army. In the future, the incorporation of LANTIRN navigation and targeting pods widely throughout the F-16 fleet will enable the employment of precision weapons around the clock.

F/A-18

The Navy operated approximately 90 F/A-18A/Cs from 4 carriers during Operation Desert Storm, and the Marines employed 72 F/A-18s from Shaikh Isa. These multirole aircraft performed a wide variety of roles in Operation Desert Storm:

- Offensive counterair missions throughout Iraq
- Combat Air Patrol (CAP) missions to protect the carrier battle groups
- Defense suppression
- Strategic attack
- Battlefield preparation and interdiction
- Killer Scout missions

The F/A-18s were the only aircraft tasked for both air-to-air and air-to-surface missions on a continued basis throughout the war.

Some F/A-18s carried FLIR pods to assist in target acquisition and night operations, although there were not enough pods to go around. Most of the air-to-surface missions for the F/A-18 employed "iron bombs"—Mk-83s (1000 lb bombs), Mk-84 (2000 lb bombs), and Mk-20 Rockeye cluster bomb units. On a few missions, the F/A-18s used Maverick and Walleye precision weapons, but like the F-16s for the Air Force, the F/A-18s relied upon their computer-aided weapons delivery systems to employ free fall weapons.

Early on, F/A-18s concentrated on strategic attacks against naval targets in the Basra area, on lethal defense suppression with HARMs, and on escort of strike packages. As the campaign proceeded, the F/A-18s shifted to attacks on the Republican Guard divisions along the Iraq-Kuwait border, Killer Scout missions, battlefield preparation, and direct support for ground forces. Marine F/A-18s flew some close support. The Navy F/A-18s generally conducted attacks against deeper targets. A steady growth in F/A-18 sorties against Iraqi ground force targets in the KTO can be seen as the war progressed. By the end of the campaign, F/A-18s were operating mainly on air-to-surface missions in the KTO.

Employment tactics for the F/A-18s mainly consisted of high-altitude deliveries with release altitudes above 10,000 ft. These aircraft experienced the same problems encountered by the F-16 force when delivering free-fall weapons from longer slant ranges. Similar to the F-16s, the F/A-18s with air-to-surface weapons loads were range-limited and depended heavily on air refueling.

F-111F

In addition to its contributions attacking bridges and airfields, the F-111F performed an important job in the defeat of the Iraqi army—tank plinking. Tank plinking was the engagement and destruction of Iraqi armor with GBU-12 laser-guided bombs. The F-111Fs used their Pave Tack IR sensor pods to locate tanks and other vehicles in revetments and then to laser-designate the armored vehicles to guide GBU-12s to the target. The tank plinking mission began as a trial with two aircraft on February 5. The next day, 43 tank plinking sorties were flown. Two days later, 30 F-111Fs were tasked in the Master Attack Plan for this mission, and after two more days over 50 F-111F LGB missions in the KTO were tasked daily. In fulfilling this tasking, the F-111Fs operated exclusively at night.

Tank plinking was a successful tactical innovation that capitalized on inherent system capabilities to meet the needs of an unexpected situation. The IR sensor

in the Pave Tack pod on the F-111Fs was able to detect vehicles in revetments for a period of time after sunset. This was very important, because it was difficult to distinguish between occupied and unoccupied revetments from medium altitude where attack aircraft flew to avoid the intense AAA in the KTO. The armored vehicles cooled at a different rate than the sand in which they were parked. Armored vehicles were thermally distinguishable after sunset even if they were covered with sand or hidden by camouflage. In addition to the F-111Fs, F-15Es and A-6Es were used in somewhat smaller numbers for tank plinking, with similar results.

Throughout the course of Desert Storm, the F-111Fs expended 5625 bombs, of which 4713 (81 percent) were LGBs. The GBU-12s were used for the tank plinking. Two-thousand, five-hundred and forty-two GBU-12s were expended by the 48th TFW (the F-111F wing) during the war. The hits claimed by the 48th TFW against ground force targets were: tanks/armor—920; artillery—252; vehicles—26; and SAMs/AAA—25. This would produce a hit rate of 48 percent. Considering that some of the GBU-12s were against other targets, the claimed hit rate was probably in the 50–60 percent range. Over the course of the the campaign, the F-111Fs destroyed better than 1 tank per sortie on tank plinking missions.

The success of the F-111Fs against the Iraqi ground forces in the KTO can be seen in the wide variety of tasks they performed and in anecdotal accounts of their mission results. For example, on February 9, only 5 days after the first test of this combat application, the 48th TFW assessed that they had 100 confirmed tank kills on 44 planned sorties. As the ground war approached, concerns about Iraqi artillery grew, and on February 22, 50 F-111Fs were tasked to attack artillery positions. One hundred artillery pieces were assessed to have been destroyed on these missions. The next day, 6 F-111Fs were used to attack specific points on the berms and defensive positions along the border and, on February 24, 50 F-111F sorties were again tasked to attack and destroy artillery.[2]

The F-111Fs were used in special circumstances where precision was needed. The destruction of the manifolds in the pumping stations dumping oil into the gulf was accomplished by F-111Fs with GBU-15s. In addition, on February 2, 5 F-111Fs destroyed ammunition storage sites in Kuwait City. Finally, from January 29 until the day before the cease-fire, an average of 6 F-111Fs per day were employed against the bridges along the Tigris and Euphrates rivers.

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[2]Because of its large payload, long range, and versatility, the air campaign planners considered the F-111F to be the "workhorse" of the campaign.

Through the course of the bridge campaign, the 48th claimed 160 hits on the bridges, destroying 12 and damaging 52.

It is interesting to note that the hit rate for PGMs in Desert Storm closely matched the results achieved in testing and training. The overall success rate for LGBs in the WSEP is 62 percent, which is very near the hit rate achieved in the war. For situations like Desert Storm, precision weapons have made combat results far more predictable than they have been in the past.

The F-111F provided an unanticipated contribution to the campaign against the Iraqi ground forces in the KTO. Few had anticipated the role that LGBs would play in destroying an army in the field. LGBs were envisioned to have utility against fixed targets. However, in the siege against the Iraqi army in the KTO, a potentially mobile force presented itself as a set of static targets well suited for precision attack. The F-111Fs met the challenge by using innovative tactics and techniques.

A-6E

The A-6E operated extensively during darkness and inclement weather and when target areas were obscured by smoke from oil well fires. Two squadrons that participated in Desert Storm were equipped with the latest version of the A-6, the A-6E System Weapons Improvement Program (SWIP), an upgrade that included improved avionics, night vision goggle compatibility, reliability and maintainability upgrades, and weapon system upgrades that allow use of Standoff Land-Attack Missile (SLAM), Maverick, HARM, and Harpoon antiship missiles to their full capability. These units participated in the first operational SLAM firings. During the war, the A-6 was used in the following mission areas:

- Day, night, and all-weather strikes using precision-guided and conventional weapons against point and area targets in support of strategic bombing and battlefield interdiction
- Antisurface warfare using missiles and conventional weapons against Iraqi naval units in day, night, and all-weather conditions
- Strike support suppression of enemy air defenses, including use of HARMs and delivery of tactical air-launched decoys (TALD)
- Deep strike launch of the SLAM.

Overland strike packages were launched from two battle forces: one in the Red Sea and another in the Persian Gulf. Ninety-five A-6s were used, flying 5619 sorties. A-6s were used for attacks on high-value targets, Iraqi ground forces,

Iraqi naval units, artillery, logistics sites, and armor concentrations. With the exception of four strikes early in the war, ordnance was delivered from medium to high altitude. Typical loads included 8–12 Mk-82s, 8–12 Mk-20s, 6 Mk-83s, 2–4 Mk-84s, 2 GBU-16s, or 2 GBU-10s. Gator, APAM, Maverick, Skipper, and Mk-82 LGBs were also used. Weapons were normally delivered in level flight or shallow dives using laser ranging, automatically switching to designation for LGBs. Target acquisition was done using the radar to cue the FLIR. Mission reports indicate that about one-third of the missions flown required radar deliveries because weather, smoke, or haze prevented FLIR use. A-6s were used extensively in kill box operations at night to attack dug-in troops and armor. A-6s also were used to support strike packages in SEAD by launching TALD or, for A-6s equipped with SWIP, by using HARMs to suppress enemy threat radar systems.

Twenty USMC A-6s, flying 795 sorties from land bases, attacked strategic targets (Scud repair/assembly buildings) and interdiction targets (bridges, rail yards, and ammunition storage areas). At the beginning of the war, Marine A-6s were formed into mixed strike packages (four A-6s and eight F-18s or eight F-18s and two EA-6Bs for SEAD). As the war progressed and air defenses were rolled back, strike packages were reduced to eight bombers and two EA-6Bs. A normal USMC A-6 loadout was four Mk-84s. Almost all USMC A-6 missions were flown at night. Three A-6s were lost and five damaged in combat, two early in the war during low-level attacks.

F-15E

The F-15E was the "rookie" in Operation Desert Storm. The 4th TFW received their first F-15Es in December 1988 and had achieved a limited operational capability in October 1989, less than a year before the first squadron deployed for Desert Shield. When the first squadron deployed, the second squadron was in the process of converting to the F-15E. The second squadron finished its conversion and deployed to the theater before the war started. The entire operational F-15E force was used in Desert Storm.

After deployment, the F-15Es still lacked some of the equipment considered necessary to conduct combat operations, the internal radar jamming system and the LANTIRN targeting pods. Additionally, SEEK EAGLE stores testing had not been completed for the aircraft. The aircrews averaged over 1500 hours flying time, but all were quite new to the F-15E, averaging about 100 hours time in the jet. The F-15E LANTIRN targeting pods arrived in theater less than a month before the war began. Only a limited number of LANTIRN targeting pods were

available for the F-15Es, and therefore the squadrons were limited in their ability to deliver LGBs.

As a result, Desert Storm was a "learn by doing" experience for the F-15E aircrews. Tactics and techniques for employment of this aircraft had to be mastered as the campaign progressed. From all evidence, the on-the-job training process was very successful. The F-15E force performance exceeded expectations, and this aircraft was productively employed in many unanticipated roles.

Predominant among the missions performed by the F-15Es was the night portion of the Scud hunting mission teamed with Joint STARS. Because of the demands of the Scud hunting mission, there were periods when the F-15Es were not used in the KTO. (Scud hunting is discussed in detail in other RAND studies of the war and will not be evaluated in this document.) The F-15E was also used to attack strategic targets throughout Iraq.

The type of missions the F-15Es performed against the Iraqi ground forces in the KTO changed as the capabilities of this relatively new aircraft became known. By examining the tasking for the F-15E force, it is evident that its use was constrained by the number of aircraft in the theater (even though all of the operationally ready squadrons were deployed) and the fact that there were only 8 to 16 LANTIRN targeting pods available in the theater. F-15Es were shifted from one role to another as the tactical and operational needs of the campaign changed.

The F-15Es were used, beginning on the third day of the campaign, to deliver CBU-87s against the Republican Guard positions. For the next five days, the F-15Es were not tasked for missions in the KTO. Then they resumed their attack against the Republican Guard positions. Beginning on January 27, F-15Es were teamed with Joint STARS for direct targeting missions in the KTO. These missions continued through February 3. During this period, both F-15Es and F-16Ls were used for Joint STARS targeting. From February 4–12, F-15Es were not tasked for missions in the KTO. After February 12, F-15Es were used for a variety of tasks in the KTO: tank plinking, Joint STARS targeting missions, attacking artillery positions along with F-111Fs, a few bridge attacks, and convoy/road and river reconnaissance to cut the flow of supplies. Finally, F-15Es were the lead flights used to cut the escape of Iraqi forces out of Kuwait.

The avionics of the F-15E were well matched for accomplishing the Joint STARS targeting mission. The picture produced with the SAR on Joint STARS is reported to match closely that produced by the SAR of the APG-70 radar on the F-15E. Therefore, F-15E flights and Joint STARS could communicate with one another by referring to a common picture. Initial target acquisition in either the

SAR mode or GMTT mode of the F-15E radar was facilitated with Joint STARS cueing. Then aircrews could shift to the LANTIRN navigation/targeting pod for visual acquisition and identification of Iraqi ground force targets.

The F-15E squadrons produced some spectacular mission results. The most prominent was graphically captured in the pictures of the "highway of death," the road leading from Kuwait City to Basra. The interdiction of the fleeing Iraqi forces began with a Joint STARS detection of the columns of Iraqi vehicles coming out of Kuwait City in the evening of February 27. The withdrawal was reported to the planning cell at the TACC by Joint STARS. The F-15E squadrons were called directly by the TACC and tasked to stop the column. The F-15Es had just recovered from their planned mission and had to be "quick turned" and launched. A fairly low layer of clouds over the retreating Iraqi vehicles complicated the task. However, using Joint STARS cueing, the F-15Es penetrated the clouds and delivered CBU-87s on the leading and trailing elements of the retreating Iraqi vehicles, stopping the movement out of Kuwait. Then a steady stream of aircraft of all types finished the job.

The potential capability of the F-15E was demonstrated in another singular incident. An F-15E can carry 8 LGBs. In mid-February, a two-ship flight of F-15Es, carrying a total of 16 LGBs, reported the destruction of 16 armored vehicles—a perfect record.

B-52

From the first day of the war until the end, B-52s flew sorties against the Iraqi forces every day. The B-52s began at about 25 sorties daily, and this number increased to around 35 per day as more aircraft were included and provisions were made to base these bombers closer to the theater. B-52s were targeted mainly against the Republican Guards, but for a few days they attacked supplies and artillery. Their contribution was based not on precision delivery but on the constant pressure of "around the clock" massive strikes. The psychological effects of their massive payloads were the same for the Iraqis as they had been for the Vietnamese, except the area covered in the KTO was smaller and the frequency of these emotional events for the Iraqi army was higher.

Non-U.S. Coalition Contributions

We have examined the results achieved by the principal Air Force, Marine, and Navy attack aircraft against the Iraqi ground forces in the KTO. The emphasis of this document is on these systems because we had the opportunity both to

examine their contributions and to interview the aircrews involved. There were, of course, many other aircraft employed, and their contributions were important. By mid-February, the daily attack effort consisted of about 1000 sorties. In addition, by early to mid-February, the daily contribution in the campaign against the Iraqi army in the KTO included approximately 100 sorties per day by a collection of aircraft from non-U.S. coalition air forces.

Non-U.S. coalition aircraft used in the KTO were Saudi and RAF Tornados, French and Italian Jaguars and Mirage 2000s, Kuwaiti A-4s and Mirage F-1s, Canadian CF-18s, F-16s from the UAE and Bahrain, and Qatari Alpha-Jets.

For the allies as with the USAF aircraft, mission effectiveness was largely a factor of the type of munitions delivered rather than the aircraft type. Generally their aircraft delivered free-fall, unguided munitions, and consequently it is difficult to assess their results accurately. However, they contributed as a part of the team. No matter how precise and effective a particular aircraft combination may be, in many ways the overall success of the air campaign can be attributed to numbers. Iraqi prisoners commented on the ubiquity of the air campaign. The airplanes were always present. Each Iraqi unit and soldier was only minutes away from a potentially lethal encounter from January 16 until the cease-fire went into effect. In addition, defeating a static dispersed Army requires numbers to find and destroy it.

The destruction of the Iraqi army in the KTO was the result of a team effort. Different combinations of aircraft sensors and weapons worked together to destroy the equipment of the 42 divisions located in the KTO and their will to fight.

Summary of System Effectiveness

The combined effects of different aircraft and systems brought the fourth largest army in the world to submission. The results of this conflict will be subject to increasing scrutiny as time passes, but they exceeded the most optimistic expectations. The performance of precision weapons has captured the imagination of all who examine this campaign. More importantly, the effect of precision weapons used in large numbers added a new dimension to air warfare. The ability to see enemy dispositions and movements throughout the battle area enabled air power to concentrate whenever the Iraqis moved. Surveillance sensors combined with systems that could operate around the clock took any potential sanctuary away for the Iraqis in the KTO.

Finally, credit must be given to the ubiquity of the coalition air forces. Continual coverage was provided throughout the KTO. To an Iraqi soldier on the ground, coalition attack aircraft were everywhere. This required many aircraft, careful advanced planning, and a versatile control system that could shift assets where they were most needed. Although we will never have an exact scorecard, we recognize that flexibility, precision, and persistence allowed the coalition air forces to make a much greater contribution to defeating an opposing army than has ever been seen in the history of warfare.

7. A Perspective on the Air Campaign in the KTO

The accomplishments of the coalition forces on land, at sea, and in the air are a remarkable milestone in military history. The fourth largest army in the world, equipped with modern weapons and seasoned over a recent extended war, was defeated in six weeks. Thirty-nine of 43 divisions deployed in Kuwait and southern Iraq were attrited and demoralized to the point where they could not conduct combat operations. The price of victory was lower than the most optimistic predictions: 143 killed, 467 wounded, and 55 aircraft lost—38 in combat. These were the accomplishments of an ad hoc coalition operating through a command and control system created over a five-month period in a region where coalition forces had not built up a military infrastructure. However, the coalition forces did have advantages in that there were a large number of militarily suitable airfields and substantial supplies of water and fuel.

The fighting strength of the Iraqi ground forces in the KTO was essentially depleted when the ground campaign began on February 24. For example, in the ARCENT/NAC areas of responsibility, the Iraqi forces in the tactical echelon had only one-third their original tanks, APCs, and artillery. The total numbers of tanks, APCs, and artillery in the ARCENT sectors were reduced to one-half the originally deployed level. Even in the MARCENT zone where the attrition rate for the Iraqi forces was lowest, the initial successes were far beyond expectations. The overall Iraqi armor and artillery in the KTO had been reduced to two-thirds their original strength when the ground war began.

For two weeks before the four-day ground campaign, a significant portion of the coalition air effort concentrated on artillery and defensive emplacements directly in front of the allied troops. The results of this effort are shown in the relative ease of the breaching operations. The fire trenches were shut down. Massive artillery barrages, a characteristic of the Iraqi forces, never appeared, and only sporadic fire was encountered elsewhere along the front during the breaching operations.

The destruction of combat equipment and the defensive emplacements are the quantifiable results of the air campaign in the KTO. Even more important is the effect that the coalition air forces had on the Iraqi troops. Judging by interviews with enemy prisoners of war (EPWs), the net effect of the air campaign was a

story of increasing hardship, a sense of helplessness, and a loss of the will to fight.

By the time the ground war began, EPW reports indicate that half the Iraqi forces had deserted. EPWs frequently commented that aircraft were always overhead. This meant that they were constantly under threat of attack. Compounding the psychological pressure was the fact that they believed that they were defenseless against the air attacks. Casualties from air attacks, on the other hand, were relatively low. By dispersing and staying away from their vehicles and weapons, they could survive. Their will and ability to fight did not outlast the air campaign, however. Debates will probably rage for a long time over whether airpower won the war, and the extent to which ground forces are necessary to seize and hold territory. However, in this conflict new conditions have emerged. In the past, air has been a support element that contributed around 10 to 20 percent to the outcome of the land battle. In this conflict, coalition air forces were responsible for 50 percent or more of the enemy ground forces losses. This represents a significant shift in the contribution of the respective forces on the outcome of the air-land battle.

The battlefield area was nonlinear. Iraqi divisions and support troops were arrayed in prepared positions throughout the KTO as shown in Figure 2.3. After the early success of the defense suppression phase of the campaign, coalition aircraft were free to range throughout the entire KTO provided they remained above the effective range of the AAA fire. As a result, any Iraqi ground force target could be attacked. Through the use of air refueling, all coalition aircraft had the range and endurance to cover the entire area. The classic distinction between CAS and interdiction blurred. Through the battle management system, flights tasked for CAS were used for interdiction and vice versa. The air campaign is better portrayed in terms of direct attack of Iraqi combat and support forces throughout the KTO. Even with precision weapons, many sorties were needed to attack and destroy the static and dispersed target set. The planning challenge was to distribute and, at times, concentrate attack aircraft across a dispersed target set to achieve the campaign goals.

This air campaign was a carefully planned, multifaceted operation. It was completed very nearly on the original schedule that developed over a five-month planning period before the beginning of the war. The conduct of the campaign differed from that of the original plan. Adaptability of the plan, the planners, and the planning system was an essential factor in the success of the campaign.

The plan provided the basic framework for the conduct of the campaign. Kill boxes, airspace control procedures, and a communications concept were

developed two weeks before Desert Storm began. The kill box structure was built upon a grid system developed by the Saudis. Its purpose was to create a procedural means to maximize the number of aircraft over target, and to avoid the predictable axes of attack inherent in the corridors that were used in Vietnam.

The complexity and scope of air-land operations in Desert Storm necessitated a centralized planning process. The dynamic integration of the airspace, communications, air refueling, defense suppression, air-to-air force protection, the command and control system, and a continuous stream of attack flights is one of the major accomplishments of Desert Storm. It is also clear that planning on this scale must be conducted and the results distributed well before the missions are actually flown. Although the planning system needs to be flexible, the battle management system must be able to adapt to shift missions on a dynamic basis as the tactical situation changes.

An important feature of the Desert Storm planning process was the innovativeness and adaptability of the planners and the operational units. Battle conditions and the tactical environment will always be different than anticipated. Adaptability is necessary. It is not unusual for pilots to devise tactical innovations in combat, but these changes are not usually institutionalized quickly. Desert Storm was different. Scud hunting, Joint STARS targeting, Killer Scouts, and tank plinking were all unique missions created for this specific conflict. They were tested, accepted, and incorporated into the Master Attack Plan and the ATO in less than a week. The time span from invention to incorporation as an institutionalized part of the campaign with established procedures in the Airspace Coordination Order was less than a week in each case. It is hard to imagine a more responsive process.

A final key aspect that facilitated the planning process during Desert Storm was the personal interactions that took place throughout the system. Each wing had its own "agent" at the TACC to act as a planner and facilitator. The planners in the "Black Hole" were people who had worked with one another over the years and had confidence in one another's ability. People working with others they knew and trusted made the system work during Desert Storm. Many have commented that the USAF dominated the planning process. Although the opportunity existed for other nations and services to play, they did not have the advantage of years of working together that Air Force planners had and they might have been overlooked at times because they were an unknown quantity. This problem can be fixed in the future.

In examining the campaign against the Iraqi ground forces in the KTO, it is easy to focus on the scope of the accomplishments and the effectiveness of particular

systems. Perhaps the most important factor in the entire campaign was the early establishment of air superiority. Creating conditions where the coalition air forces could operate without having to contend with threats from Iraqi aircraft or surface-to-air defenses made all other operations successful. It permitted continuous presence over the battle area in the KTO. Without first establishing air superiority, the war would have been very difficult, if not impossible, to wage.

The air-land campaign in the KTO during Desert Storm gave a glimpse into the changing nature of modern warfare. These changes are the product of new technology used by people trained under realistic conditions. The systems that produced dramatic changes in warfare conduct fell into two categories. First, there were weapon systems that had been in the force for a decade or more but had not been used extensively in combat. And several new systems which had just become operational or were still in development had a large effect in the campaign even though they were not available in numbers.

Precision-guided weapons worked. Tests and training had predicted success. A few Maverick and LGBs had been used at the close of the Vietnam War. The overall effect of employing these weapons in large numbers was a dramatic discovery. The effectiveness of these weapons was very close to the results achieved in peacetime testing, training, and exercises. This correlation existed for Mavericks, LGBs, and air-to-air missiles. In the past, combat effectiveness has diverged significantly from test and training results. It appears that the relative ease of employment of modern weapons has made results more predictable. This ability to engage and destroy targets with assurance will change the nature of the planning process and increase the demand for timely and accurate BDA.

Operation Desert Storm was the first time that effective large-scale nighttime air operations have been conducted. IIR sensors combined with precision navigation aids, off-board cueing, and effective weapons have opened the night window. Operating at night allowed 24-hour pressure on the enemy ground forces and neutralized many enemy defenses. Effective night operations are a significant qualitative edge that will give our forces an advantage for years to come.

Joint STARS was a developmental platform supported by contractors and operated by a select group of specialists when the invasion of Kuwait took place in August 1990. It demonstrated an important ability to detect ground force and logistics movements far behind enemy lines. The engagement of two reinforcing Iraqi divisions inside Kuwait during the battle of Khafji and the columns of Iraqi vehicles fleeing from Kuwait at the end of the war are striking examples of this

system's contribution. Joint STARS and other wide-area sensors now permit direct engagement of enemy forces at depth throughout the battlefield. The engagement time lines for attack aircraft against moving ground forces permit concentration across the battle area. The view of the battle area combined with effective weapons makes it extremely difficult to move ground forces against an opponent that can gain local air superiority.

The GPS was new; only two squadrons of F-16s out of the entire force were equipped with it. We have only a foretaste of this system's potential. However, those who used it were very impressed, and the prospect of conducting future campaigns with reference to a common grid system offers many new applications and opportunities for increased situation awareness and for planning and conducting joint force operations.

Joint STARS, GPS, LANTIRN, and the F-15E were all new systems. When they are applied in numbers, they could begin a revolutionary change in the nature of combat, as happened with the use of many PGMs.

Behind the planning, the aircraft and weapons, and the remarkable results achieved against the Iraqi army in the KTO are well-trained and motivated people. A decade or more operating with a volunteer force trained under realistic conditions yielded a high payoff against the Iraqi forces. The people operated with proficiency under demanding and changing conditions, and displayed the flexibility to adapt to the situation. This war could also signal the end of the period where a conscript force can compete with a dedicated professional fighting force. In the end, people were the factor that led to the victory in the desert.

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